SP-024

manual for condition rating of flexible pavements

distress manifestations

Technical Report Documentation Page

Manual for Condition Rating of Flexible Pavements – Distress Manifestations

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Abstract:	Most highway authorities use pavement surface condition ratings to judge the pavement's ability to continue providing required service to the public. The Ministry of Transportation of Ontario uses two interrelated measures, riding quality and distress manifestations, as the basis of its condition rating scheme. To meet the Ministry's pavement management need this manual was prepared and provides the what, why, and how of pavement condition rating for flexible pavements. This document is also suitable for adaptation by municipal road agencies in Ontario.
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1/ Introduction

Rating of pavement surface condition is used in one form or another by most highway authorities as a measure of the ability of the pavement to continue to provide service to the public. Condition ratings are used in determining deficiencies, inadequacies, remedial measures, fiscal needs, and in programming. The surface condition rating scheme used in Ontario is based on two interrelated measures — riding quality and distress manifestations.

Riding quality, although it is a subjective measure depending on personal opinion, regional bias, and observer experience, can be measured quantitatively by mechanical devices. Distress manifestations have not previously been quantified, but quantification is necessary if more meaningful use is to be made of condition ratings.

In this manual, distress manifestations are categorized, and illustrations of each category are provided to lend uniformity to reporting and interpretation. In addition, descriptions of the density of occurrence and the severity of each type of distress manifestation are made to conform to standard words which precisely express the relative density or severity on a scale of 1 to 5. For example, in the description "slight multiple longitudinal wheel-track cracks occurring at frequent intervals over the section," the words *slight* and *frequent* are the standard words which correspond to Numbers 2 and 3, respectively, on the severity and density scales. Guidelines and photographs are provided to control the use of standard words.

Probable causes of each distress manifestation are presented, together with comments on progressive deterioration or other behaviour which might affect remedial treatment.

Although the purpose of this manual is to describe distress manifestations, possible remedial measures are included under each distress manifestation. However, the remedial measures listed against a deficiency are not necessarily the most effective maintenance alternative; nor will these measures necessarily effectively correct the cause or causes of the distress. The listed remedial measure may be only an expedient maintenance treatment to slow deterioration.

2/ Pavement Surface Condition Rating Scheme

The rating scheme devised and currently used in Ontario is shown in Table B-1 of Appendix B. It presents a rating scale of 0 to 100 and the locations on this scale for separating different timing and types of remedial action, together with corresponding descriptions of surface condition in terms of riding quality, distortion, and the severity, extent and type of cracking distress. The scheme is valid; however, more value can be obtained from Condition Reports if a formalized and uniformly-worded description of each distress manifestation is implemented. Such descriptions are a decision-aid in choosing the remedial treatment with the best probable chance of success. Standard descriptions also assist in performance evaluation of different pavement designs, they allow identification of specific problems or weaknesses, and they permit quantitative analysis of the type, extent, and location of distress manifestations.

To do a condition rating, the rater evaluates two physical parameters:

- the riding quality of the pavement surface (the indicator for pavement functional condition); and
- the extent and severity of pavement surface distress manifestations (the indicator of pavement structural condition).

The two physical parameters are interrelated by reason that some distress manifestations result in surface distortion and unevenness which, in turn, cause a reduction in riding quality. A prime example is transverse crack lipping or cupping, which results in a rough ride for road users. Rougher pavements, in turn, cause vehicles to produce higher dynamic wheel loads, which increase stresses, strains, and deflections and thus hasten pavement deterioration. However, not all distress manifestations are accompanied by distortion or unevenness. The type of distress and the extent and severity of occurrence are all very useful indicators of structural inadequacy, materials deficiency, and probable rate of subsequent deterioration.

Although riding quality is a perceived measure, it is quite practical for the experienced rater to evaluate ride quality. The ability of the rater to provide a subjective, yet reliable, measure of ride comfort using the guidelines will improve with rater experience. Mechanical measurements using such roughness devices as the Mays Meter, PURD, or the ARAN may be made in lieu of subjective riding comfort rating; however, the numerical value measured by these mechanical devices must be equated to the same subjectively-derived riding comfort rating scale.

Distress manifestations of pavement surface may be grouped under three main headings:

- surface defects;
- distortion or permanent deformation; and
- cracking.

The different distress manifestations have been assigned names, which are listed in Figure 1. For each type of distress, a description of physical appearance and an array of possible causes are given. Each type of distress is evaluated in terms of the extent or density of occurrence, and in terms of severity. Uniform descriptions are given to correspond to each category of density or severity.

A pavement condition rating based on the two physical parameters should reflect the average condition of the pavement section rated. This requires that roads be divided into sections exhibiting relatively uniform performance. In general, sections should start and end at major intersections. A preliminary evaluation of riding quality should enable the rater to identify sections with substantially different qualities, and the project may be subdivided according to these variations. However, it is suggested that in rural areas the subsection should not be less than 1.6 km and, in the case of urban streets, not less than the distance between two intersections (if uniform in performance appearance). Intersections should be included as part of the evaluation section in both rural and urban situations.

Pavement condition ratings are to be carried out in late spring or in summer to allow for the effects of frost heaving to dissipate, and to allow the pavement to stabilize.

Pavement shoulder distresses, although not directly affecting the pavement surface condition, do contribute to overall pavement performance. Therefore, evaluations should round out the total performance picture. For practical purposes, only paved or bituminous stabilized shoulders are considered, and the distresses are grouped under the following headings:

Paved full or paved partial shoulder

- Cracking
- Pavement edge/Curb separation
- Distortion

Surface treated

- Breakup/Separation
- Edge break

Primed

- Breakup

Maintenance treatments carried out on the pavement surface do contribute directly to overall pavement performance, especially the pavement's functional condition, because treatments can and do directly affect the riding quality of the pavement surface. Therefore, reporting on the type and extent of maintenance treatment carried out on the pavement is both desirable and necessary.

Although the purpose of the rating scheme is to describe distress manifestations of the pavement, possible matching remedial measures are also suggested under each distress manifestation for maintenance action. However, it should be understood that the possible remedial measures suggested for a deficiency might not necessarily be the most effective maintenance alternatives, nor will these measures necessarily effectively correct the cause or causes of the distress. That is, the listed remedial measures may only be expedient maintenance treatments to slow the deterioration.

Complete and uniform condition reports should lead to increased confidence in planning. Also, pavement condition ratings should be done at regular time intervals so that management can be aware of changing conditions and can plan maintenance and rehabilitation with confidence. The preferred interval is one year but, if this is not feasible or economical, the maximum interval is three years.

Figure 1/ Distress Manifestations and Maintenance Treatment Alternatives

Pavement Distress Manifestation	Evaluation		
	Severity	Density	Other Characteristics
Surface Defects			
• Coarse Aggregate Loss & Ravelling & Segregation			
• Flushing			
Surface Deformations			
• Rippling and Shoving			
• Wheel Track Rutting			
• Distortion			
Cracking			
• Longitudinal Wheel Track			
• Longitudinal Meander and Mid-lane			
• Centre Line			
• Pavement Edge			
• Transverse			
• Map			
• Alligator			
Shoulders **Dominant Distress Type**			
• Cracking			
• Pavement Edge/Curb Separation			
• Distortion			
• Breakup/Separation			
• Edge Break			
• Breakup			
Maintenance Treatment			
Pavement			
• Manual Patching			
• Machine Patching			
• Spray Patching			
• Rout and Seal Cracks			
• Chip Seal			
Shoulders			
• Manual Patching			
• Machine Patching			
• Rout and Seal Cracks			
• Chip Seal			

3/ Procedure for Pavement Evaluation

Step 1 To carry out the pavement condition evaluation, drive slowly over the pavement to visually inspect its overall surface condition for uniformity in appearance. If distinct differences are observed, then the pavement should be subdivided into two (or more) appropriate sections for evaluation.

However, each evaluation section should have a minimum length of 1.6 km for rural roads, and the distance between two intersections (regardless of length) for urban streets. This minimum length requirement is strictly for economic reasons.

Step 2 After establishing the evaluation section, assess the pavement functional condition by obtaining the Ride Condition Rating (RCR). This rating is obtained by averaging the ride quality of both directions of the pavement. Drive over the pavement at the posted speed limit; however, if it is not possible to maintain the posted speed limit safely, the pavement should be rated at a safe speed and that speed should be noted. For an urban situation where the evaluation section covers more than one block with intervening stops, traffic regulations must be observed, but the RCR should be obtained by averaging the whole evaluation section.

Step 3 After determining the RCR, assess the pavement structural condition by driving over the pavement slowly to assess distress manifestations (maximum speed not to exceed 50 km/h for rural roads, or 30 km/h for urban streets). Two or three stops per section should be made to examine distress type and severity, particularly with respect to surface conditions and surface deformations.

Step 4 Complete the Pavement Condition Rating Form by recording the Ride Condition Rating and all observed distress manifestations, shoulder distress manifestations, and maintenance treatments in their appropriate places (Figure A-1, Appendix A).

Step 5 Assign a Pavement Condition Rating (PCR) according to the guide for the estimation of pavement condition rating for Flexible Pavements (Table B-1) given in Appendix B.

4/ Riding Quality (Ride Condition Rating)

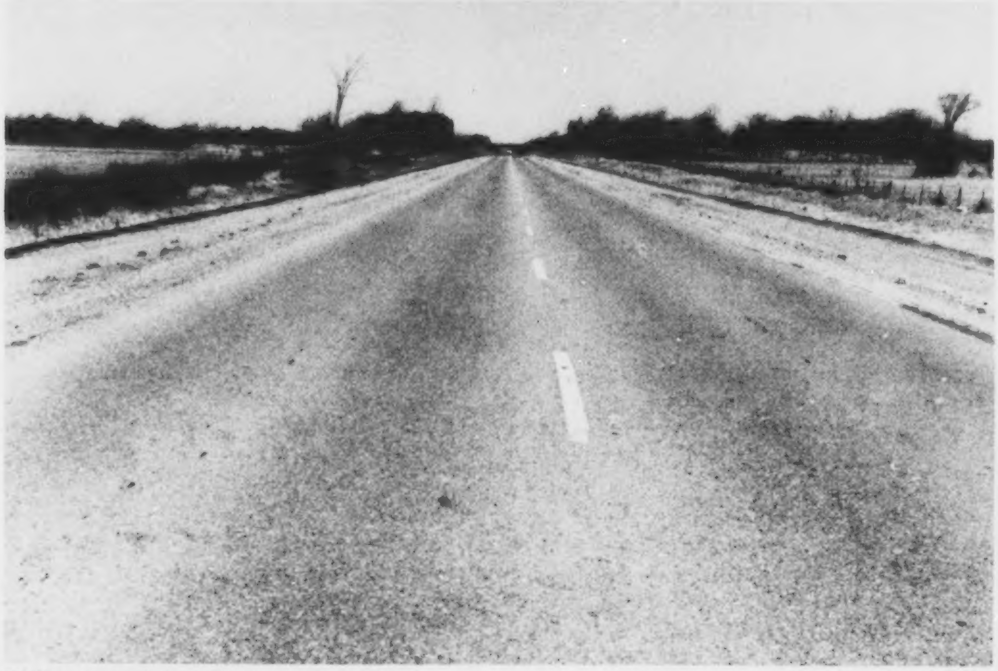
The riding quality of pavement is the degree of riding comfort which the pavement provides to the travelling public. The rater should drive over the pavement section at the posted speed and, having done so, classify the pavement's riding condition according to the descriptions given in Table 1.

Perhaps surprisingly, the type of passenger vehicle used to perform this Ride Condition Rating has no significant influence on the evaluation. This finding was reported in an experimental study conducted by MTO in 1968, in which over 100 individual raters used different types and sizes of automobiles (1). Therefore, it is not necessary to specify any particular vehicle for assessment of the riding quality (Ride Condition Rating) of the pavement surface.

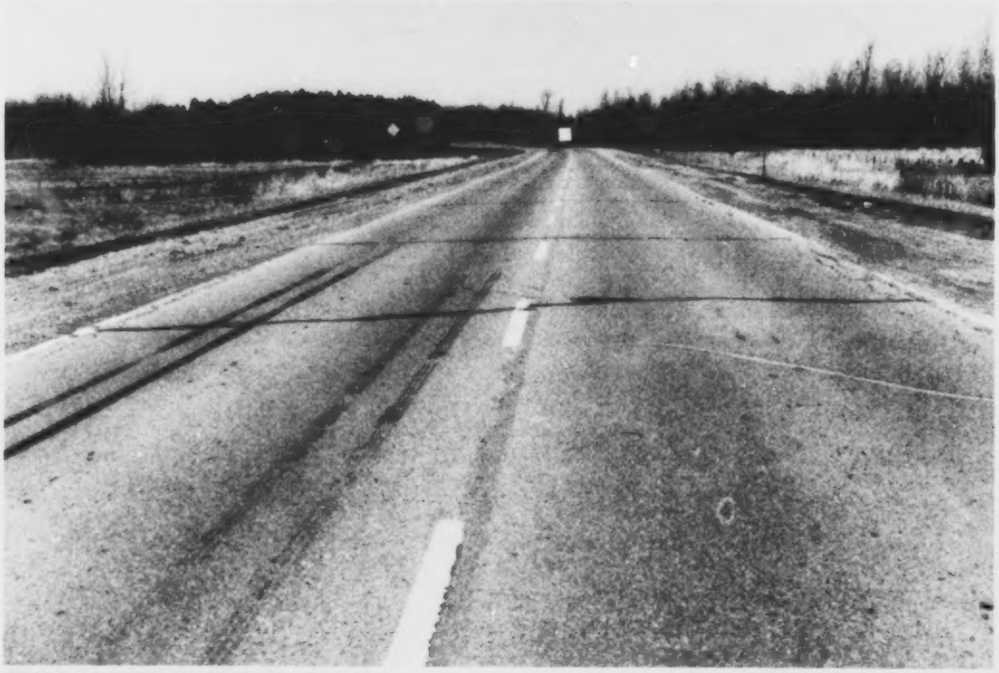
When rating riding condition, it is important that the rater try not to be influenced by the *appearance* of the pavement surface or by the pavement's class – only the riding quality the pavement provides to the rater should be considered relevant.

Table 1/ Ride Condition Rating Guide

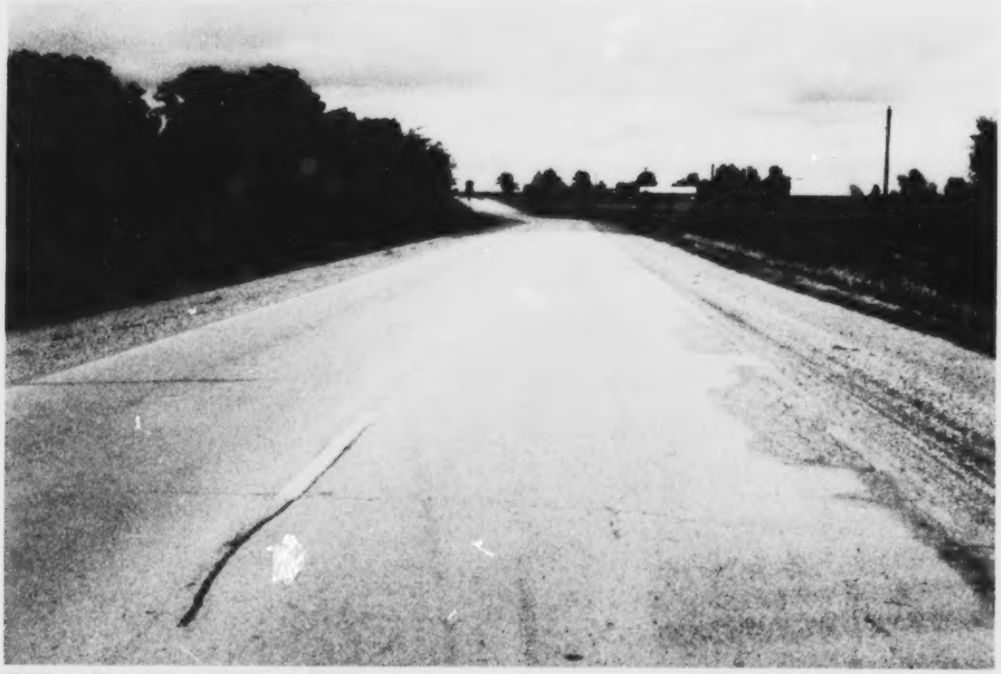
RCR	Uniform Description of Ride Condition at Posted Speed (RCR)	Guidelines
8-10	Excellent	Very smooth ride.
6-8	Good	Smooth ride with just a few bumps or depressions.
4-6	Fair	Still comfortable ride with intermittent bumps or depressions.
2-4	Poor	Uncomfortable ride with frequent bumps or depressions.
0-2	Very Poor	Uncomfortable ride with constant bumps or depressions resulting in rattle and shake of rating vehicle. Cannot maintain posted speed and must steer constantly to avoid bumps or depressions. Dangerous at 80 km/h.



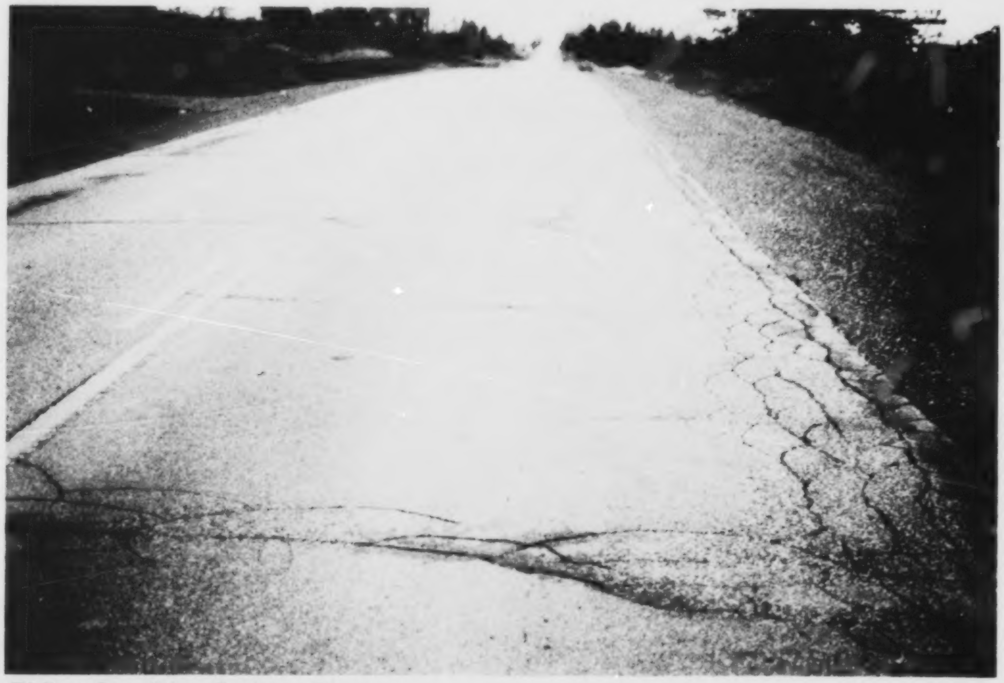
Riding Condition Rating: Excellent



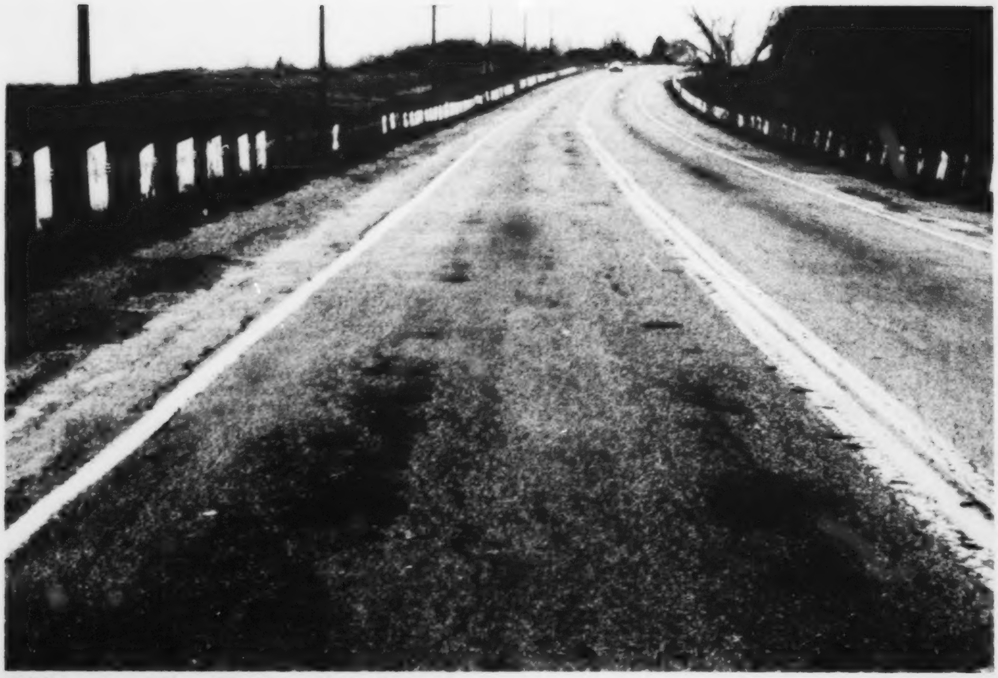
Riding Condition Rating: Good



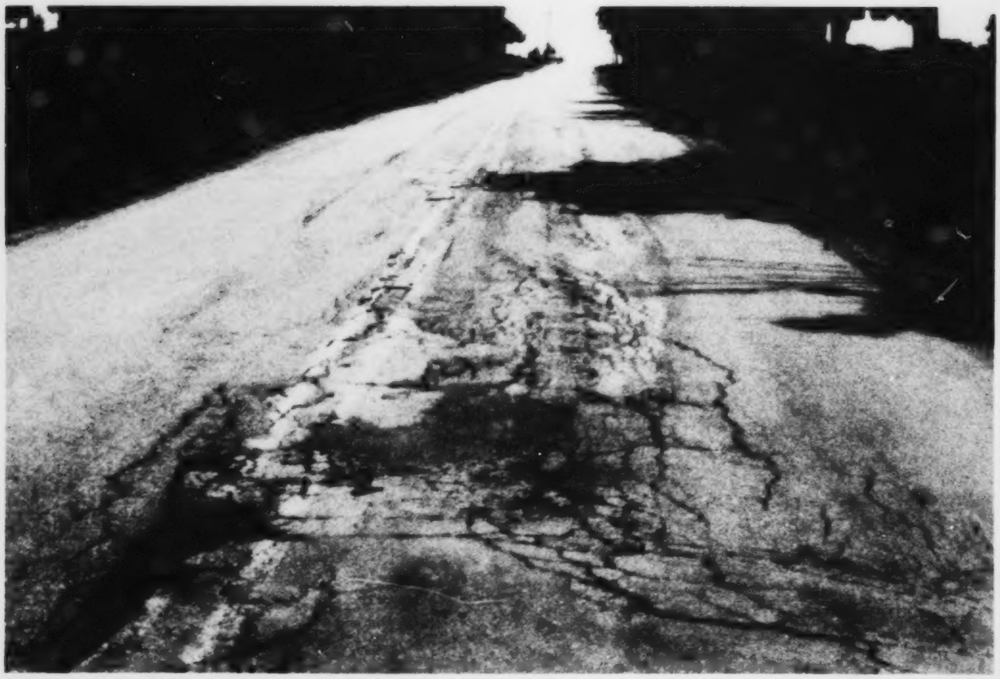
Riding Condition Rating: Fair



Riding Condition Rating: Poor



Riding Condition Rating: Very Poor



Riding Condition Rating: Very Poor

5/ Distress Manifestations

Distress manifestations are visible signs of pavement structural condition. These distresses are indicators of problems due to material deficiencies, construction deficiencies, environmental and climatic conditions, traffic loading, or other causes. The degree of severity (How bad?) and density or extent of occurrence (How big?) of these distresses are good indicators of the problem.

Severity

The term "severity" simply indicates *how bad* the problem is. It is a scale based on past engineering experience. It has five levels – Very Slight, Slight, Moderate, Severe and Very Severe. These Guidelines give a verbal description of each stage, along with pictorial representations.

Density (Extent of Occurrence)

The term "density" simply describes *how big* the problem is. It, too, is based on past engineering experience. It has five levels – Few, Intermittent, Frequent, Extensive and Throughout. These Guidelines give a verbal description of each stage, based on the percentage of surface area affected and where it is affected.

For example, the rater may encounter a situation where there are some incidences of flushing located within a short distance of each other and, within the evaluation section, this distance represents between 10% and 20% of the pavement surface area. Thus, the "density" is said to be "intermittent" (Figure 2).

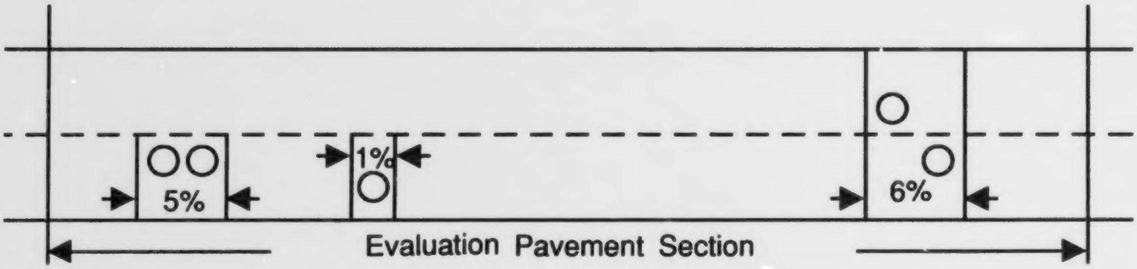


Figure 2 Intermittent Occurrence of Flushing

On the other hand, if these same occurrences of flushing are spaced over the length of the evaluation section, the density is still "intermittent" because there are only isolated incidents over a few areas of the total pavement surface (Figure 3).

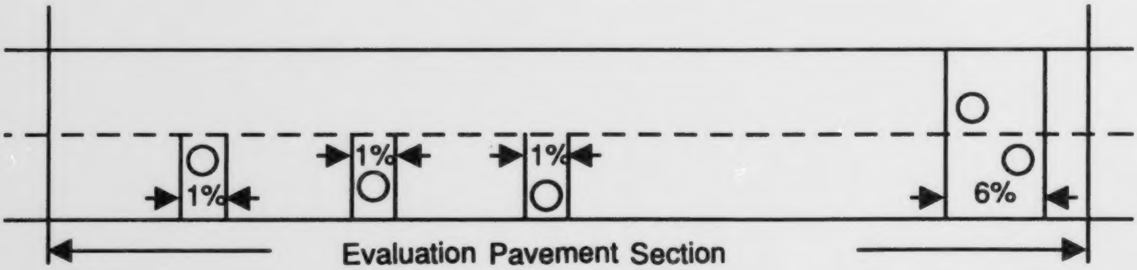


Figure 3 Intermittent Occurrence of Flushing

However, if these occurrences of flushing are present in clusters covering more than 20%, and up to 50%, of the pavement surface, the density is said to be "frequent" (Figure 4).

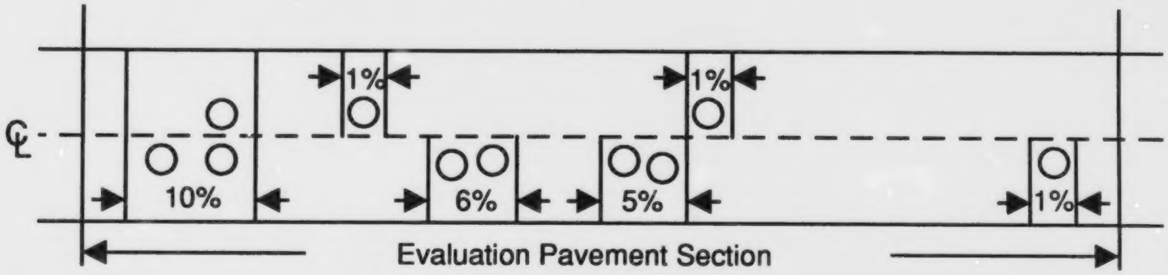
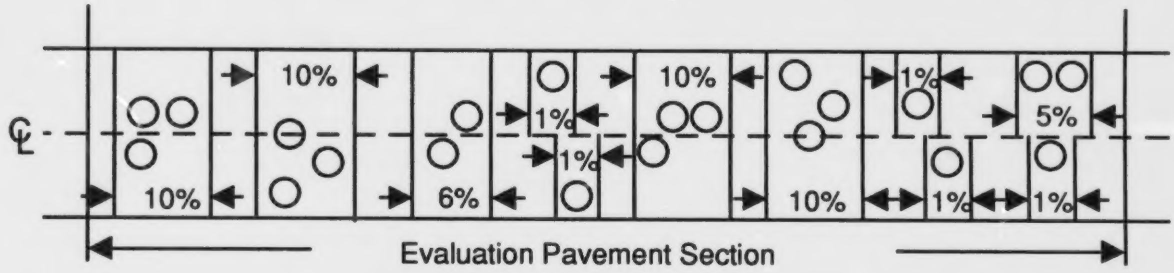

1%
1%
℄
10%
6%
5%
1%
Evaluation Pavement Section

Figure 4/ Frequent Occurence of Flushing

For "extensive" occurrence, flushing is present over the length of the pavement section and covers from 50% to 80% of the surface area (Figure 5).


10%
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1%
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1%
10%
6%
10%
1%
1%
Evaluation Pavement Section

Figure 5/ Extensive Occurrence of Flushing

It should be noted that "coverage" here means that 20% to 50% of the pavement surface area has flushing. It does not mean flushing represents 20% or 50% of the pavement surface. These illustrations serve generally for all distress manifestations.

5.1/ Surface Defects

Loss of Coarse Aggregates. Ravelling (Segregation)

Flushing

Loss of Coarse Aggregates. Ravelling (Segregation)

Description:

Pavement surface looks as though it is breaking up into small pock-marks as coarse aggregate particles are lost from the surface; or progressive loss of pavement materials (coarse or fine aggregates, or both) from surface downward results in a pock-marked appearance; or pavement surface has the appearance of an open matrix with all coarse aggregates only showing in spots.

Possible Causes:

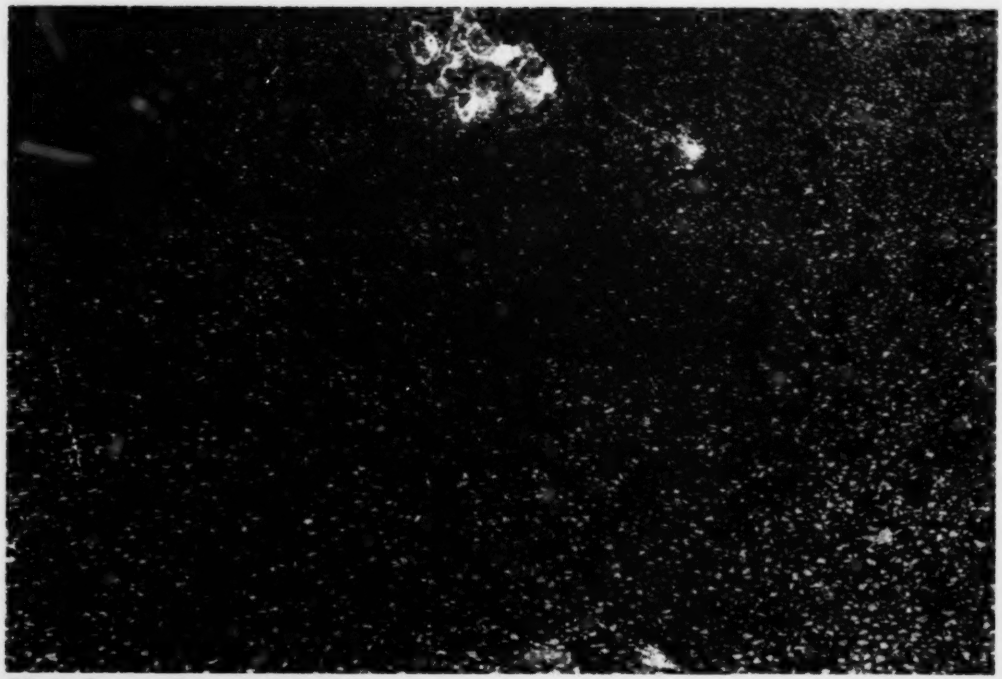
1. Lack of bond between particles and mortar due to inadequate coating or to stripping under the action of water.
2. Fracture of the particles through load or natural causes, allowing the loosened pieces to be picked out by traffic action.
3. Disintegration of particles, such as chert, which are highly absorptive, and fracture and disintegrate upon repeated freezing and thawing.
4. Delamination of chert or shale particles.
5. Clay-coated aggregate particles.
6. Insufficient asphalt content.
7. Poor adhesion of asphalt binder to aggregate particles due to wet aggregate.
8. Poor compaction – especially cold weather paving – permits infiltration of water and salts which promote stripping of asphalt.
9. Asphalt hardening due to aging.
10. Poor construction practices such as improper storage bins, loading of truck, paving equipment trains, etc.

Severity:

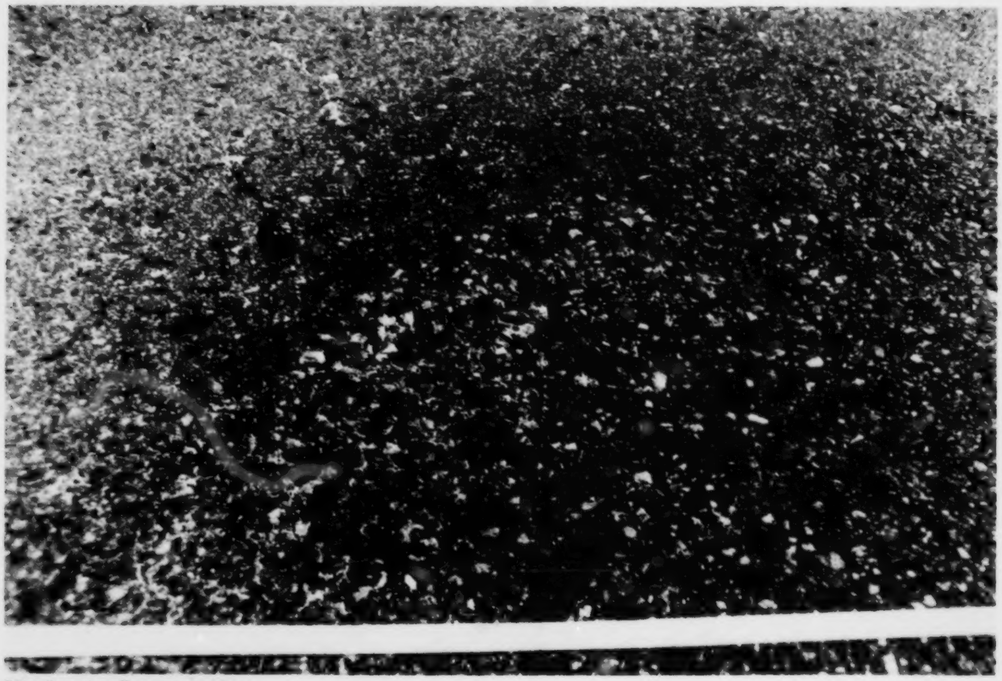
Class	Guidelines
Very Slight	Barely noticeable.
Slight	Noticeable loss of pavement materials.
Moderate	Having pock-marked appearance, fairly well spaced between pock-marks. Shallow disintegration of pavement surface, an open-textured look.
Severe	Having pock-marked appearance, pock-marks are closely spaced. Disintegration with small potholes or veined with slight cracks.
Very Severe	Surface has a ravelled appearance and is disintegrated into large potholes or veined with moderate cracks.

Density:	**Class**	**Guidelines**
	Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
	Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
	Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavement section or over localized areas only.
	Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section .
	Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.

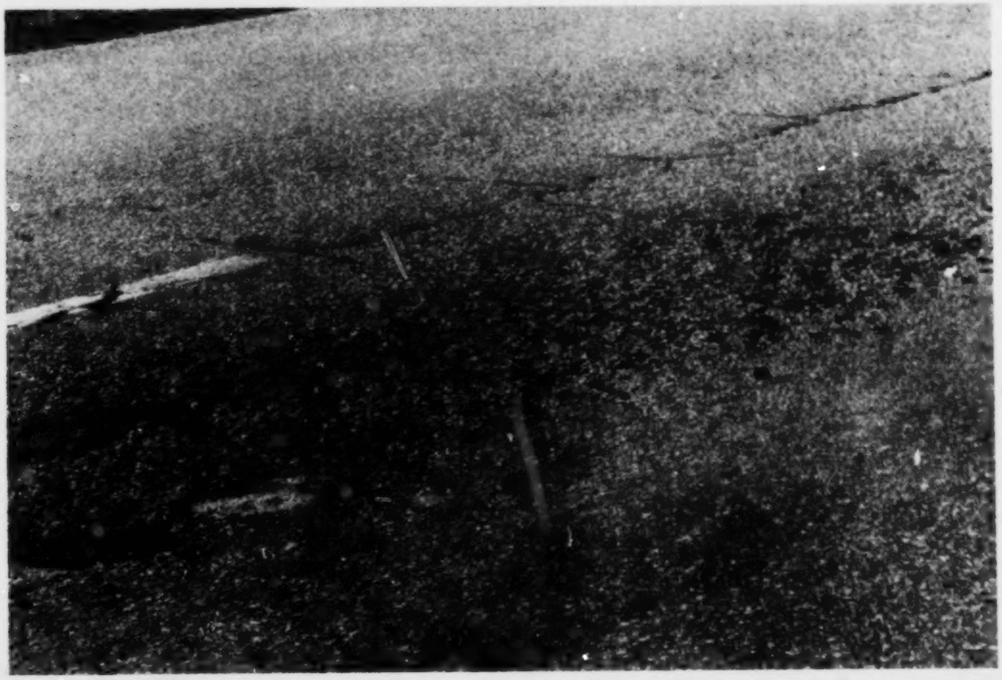
Very Slight Ravelling



Slight Coarse Aggregate Loss



Moderate Segregation



Severe Ravelling

Very Severe Ravelling

Treatment

Evaluation		Suggested Remedial Measure Alternatives
Severity	**Density**	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Slight	Few	• None
	Intermittent	• None
	Frequent	• None • Fog Seal
	Extensive	• Fog Seal
	Throughout	• Fog Seal
Moderate	Few	• No Action • Manual Spray Patching • Manual Chip Seal
	Intermittent	• Manual Spray Patching • Manual Chip Seal
	Frequent	• Manual Chip Seal
	Extensive	• Manual Chip Seal • Machine Chip Seal • Fog Seal • Surface Treatment • Hot-Mix Asphalt Resurfacing
	Throughout	• Fog Seal • Surface Treatment • Hot-Mix Asphalt Resurfacing
Severe	Few	• Manual Chip Seal
	Intermittent	• Manual Chip Seal
	Frequent	• Manual Chip Seal • Machine Chip Seal • Machine Patching
	Extensive	• Machine Chip Seal • Machine Patching • Surface Treatment • Hot-Mix Asphalt Resurfacing
	Throughout	• Surface Treatment • Hot-Mix Asphalt Resurfacing
Very Severe	Few	• Manual Chip Seal
	Intermittent	• Manual Chip Seal
	Frequent	• Manual Chip Seal • Machine Chip Seal • Machine Patching
	Extensive	• Machine Patching • Surface Treatment • Hot-Mix Asphalt Resurfacing
	Throughout	• Surface Treatment • Hot-Mix Asphalt Resurfacing

Flushing

Description:

The presence of free asphalt binder on the pavement surface, resulting from upward migration of the binder. Most likely to occur in the wheel tracks during hot weather.

Possible Causes:

1. Too high asphalt content relative to void content in mineral aggregate. On hot days, asphalt binder expands into air voids; if air voids are too low, continued expansion results in lower stability of the mix, with the consequence that traffic will force out excess asphalt binder to the surface.

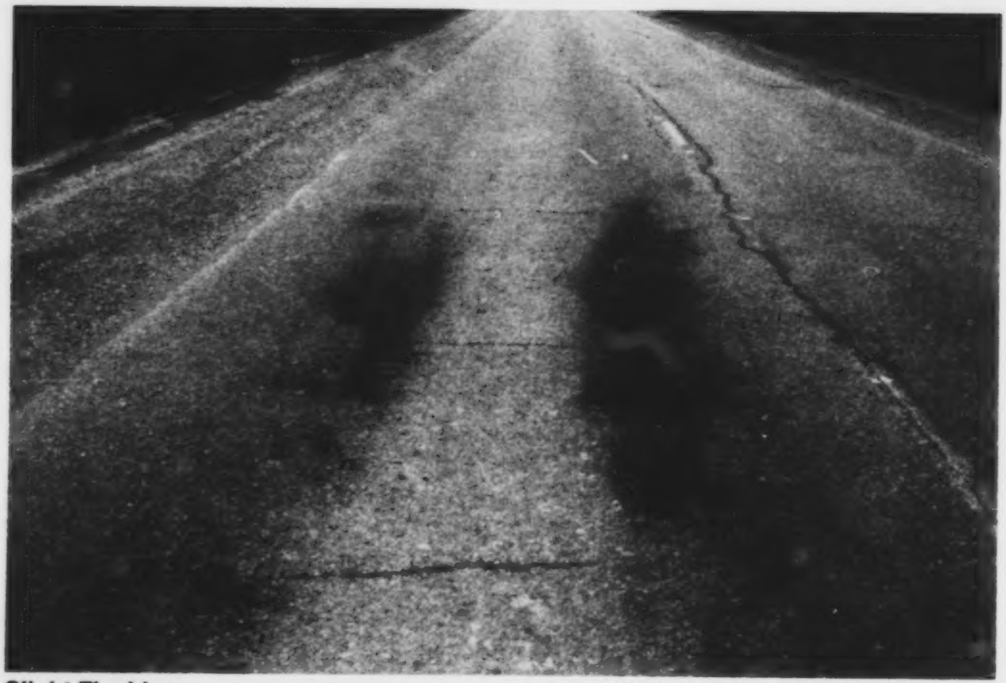
2. Paving over excess primed surfaces.

Severity:

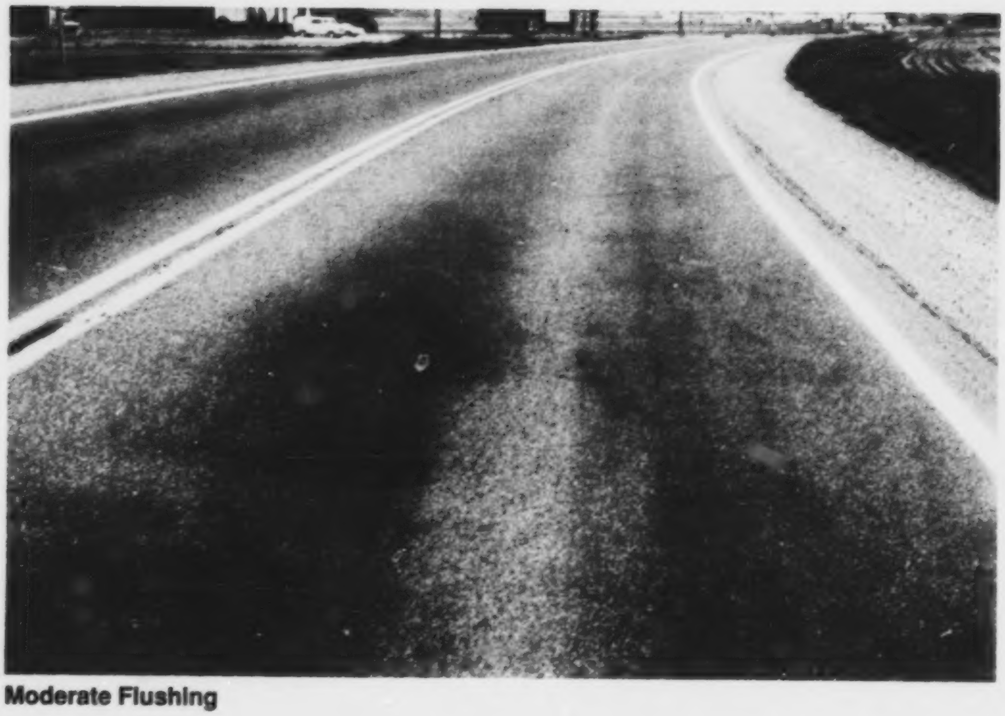
Class	Guidelines (Based on observation appearance)
Very slight	Very faint colouring (veining).
Slight	Colouring visible (interconnected veining).
Moderate	Distinctive appearance (with excessive asphaltic materials already free).
Severe	Free asphaltic materials giving the pavement surface area a wet look.
Very Severe	Free asphaltic materials giving the affected pavement surface area a wet look, and wheel noise comparable to that when driving over a water-wet surface.

Density:

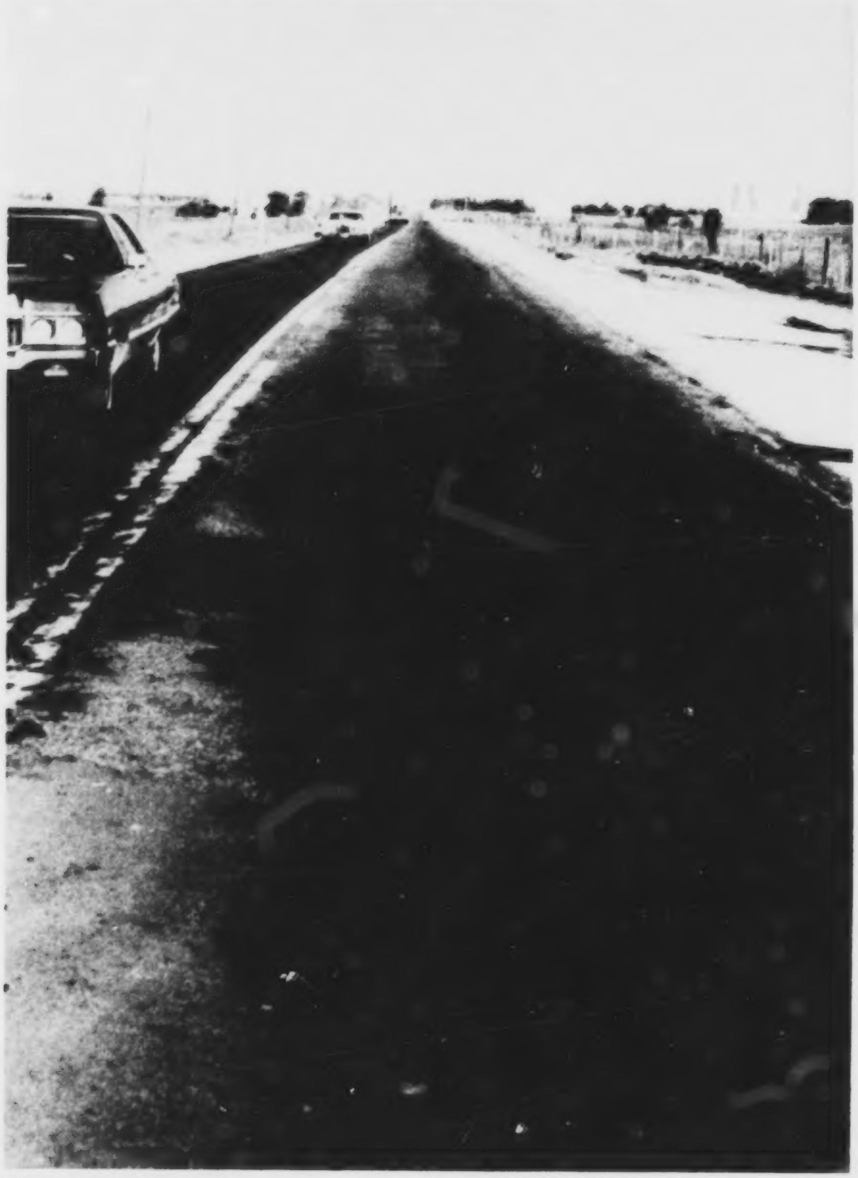
Class	Guidelines
Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavement section or over localized areas only.
Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.



Slight Flushing



Moderate Flushing



Very Severe Flushing

Treatments

Evaluation		Suggested Remedial Measure Alternatives
Severity	Density	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Moderate	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Severe	Few	• None
	Intermittent	• None
	Frequent	• Burn and Seal • Cold Mill and Replacement by Hot-Mix Patching
	Extensive	• Cold Mill and Replacement by Hot-Mix Patching
	Throughout	• Cold Mill and Replacement by Hot-Mix Resurfacing • Hot-Mix Resurfacing
Very Severe	Few	• Burn and Seal
	Intermittent	• Burn and Seal • Cold Mill and Replacement by Hot-Mix Patching
	Frequent	• Cold Mill and Replacement by Hot-Mix Patching
	Extensive	• Cold Mill and Replacement by Hot-Mix Resurfacing • Hot-Mix Resurfacing
	Throughout	• Same alternatives as for "Extensive"

5.2/ Distortion or Permanent Deformation

▨ **Rippling and Shoving**

▨ **Wheel Track Rutting**

▨ **Distortion**

Rippling and Shoving

Description:

Regular transverse undulations in the surface of the pavement, consisting of closely-spaced, alternate valleys and crests (Washboard Effect); or singular and multiple waves or humps located transversely or longitudinally on the pavement surface.

Possible Causes:

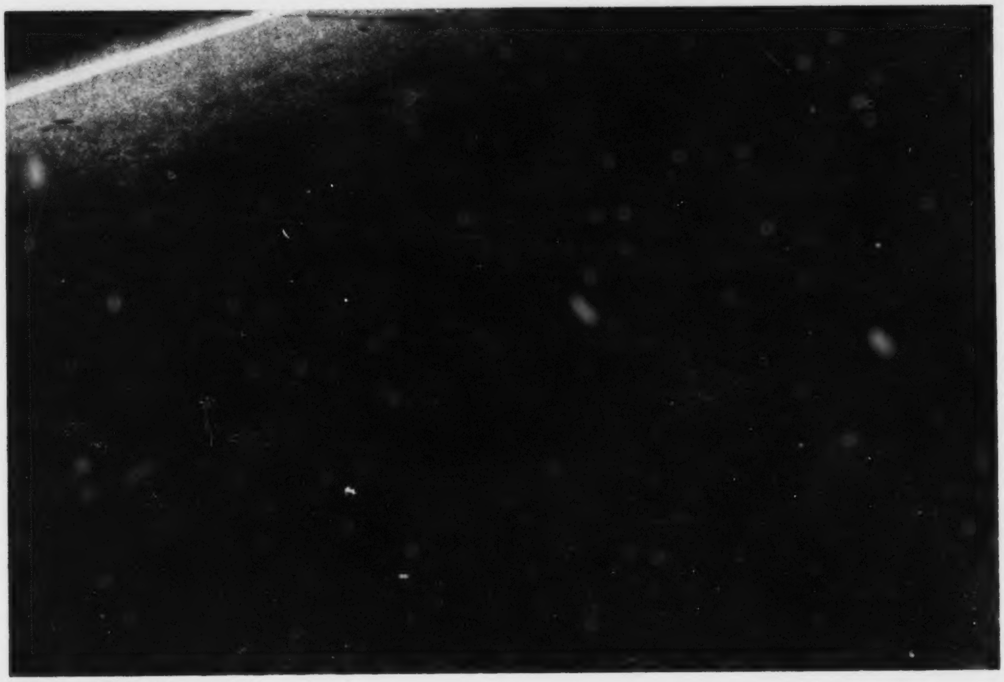
1. Faulty paver behaviour with some mixes.
2. Heavy traffic on steep downgrade or upgrade, or pavement with too thick tack coat or too thick soft waterproofing membranes on bridge decks.
3. Low stability in asphalt mix.
4. Stopping at intersection stop lights.
5. Lack of bond between asphalt surface and underlying layer — may be caused by excess tack coat acting as a lubricant.
6. Unstable granular base reflecting through the surface.

Severity:

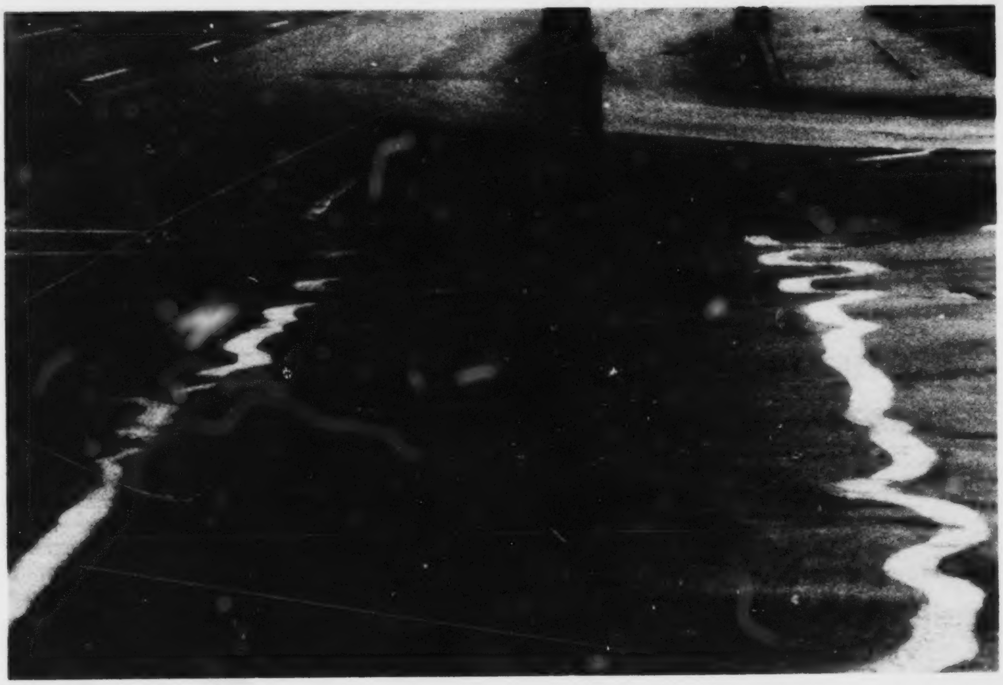
Class	Guidelines
Very slight	Barely noticeable washboard effect.
Slight	Noticeable washboard effect.
Moderate	Bumpy with washboard appearance or ridges and valleys.
Severe	Very bumpy with pronounced washboarding or large humps on pavement surface.
Very Severe	Washboarding or large humps which causes vehicles to drift sideways and may cause loss of control of vehicles.

Density:

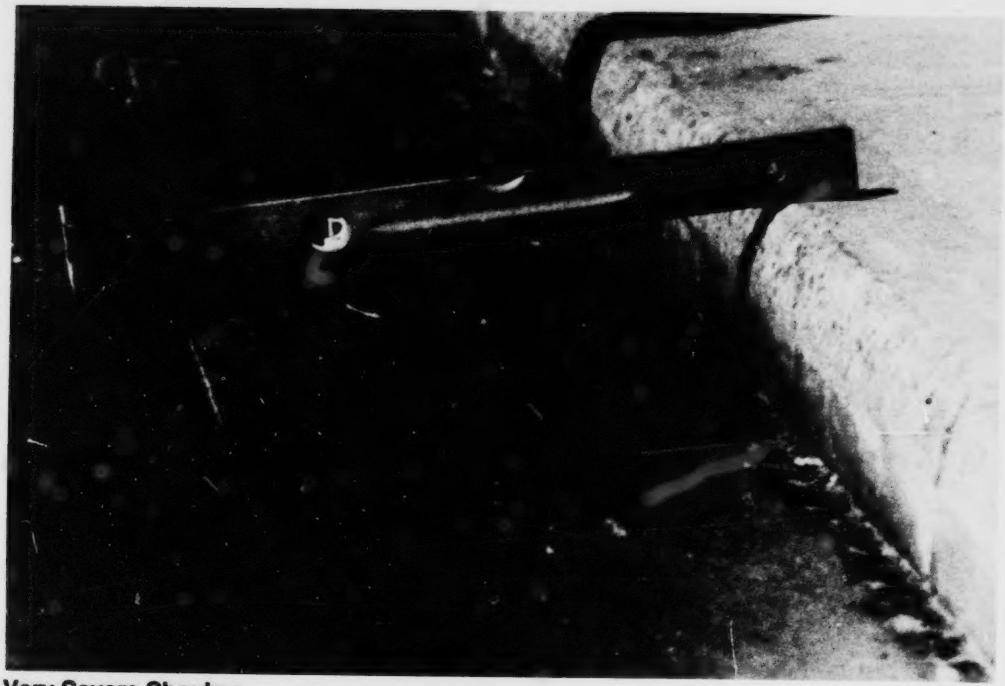
Class	Guidelines (Based on percent of surface area in the pavement section being affected by defect.)
Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavement section or over localized areas only.
Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.



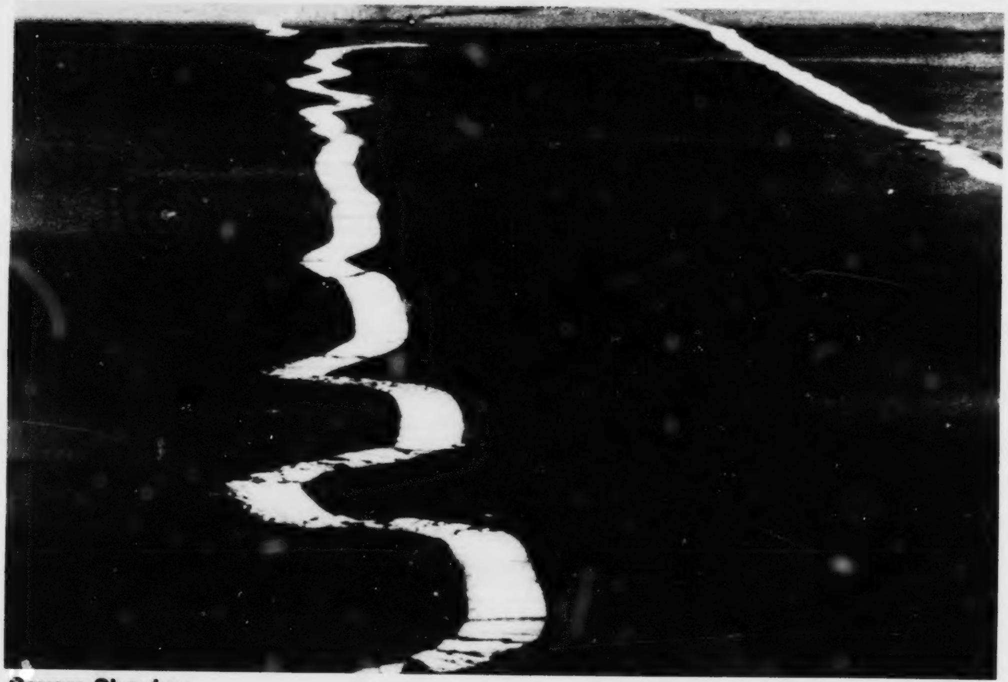
Severe Rippling



Very Severe Shoving



Very Severe Shoving



Severe Shoving

Treatments

Evaluation		Suggested Remedial Measure Alternatives
Severity	**Density**	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Moderate	Few	• None
	Intermittent	• Cold Mill with Manual Patching • Machine Patching • Cold Mill with Machine Patching • Hot Planing with Machine Patching
	Frequent	• Machine Patching • Cold Mill with Machine Patching • Hot Planing with Machine Patching
	Extensive	• Machine Patching • Cold Mill with Machine Patching • Hot Planing with Machine Patching
	Throughout	• Cold Mill with Hot-Mix Resurfacing • Hot Planing with Hot-Mix Resurfacing • Hot-Mix Resurfacing
Severe	Few	• Cold Mill with Manual Patching • Machine Patching
	Intermittent	• Cold Mill with Machine Patching • Hot Planing with Machine Patching • Machine Patching
	Frequent	• Cold Mill with Machine Patching • Hot Planing with Machine Patching
	Extensive	• Machine Patching • Cold Mill with Hot-Mix Resurfacing • Hot Planing with Hot-Mix Resurfacing
	Throughout	• Cold Mill with Hot-Mix Resurfacing • Hot Planing with Hot-Mix Resurfacing
Very Severe	Few	• Cold Mill with Manual Patching • Machine Patching
	Intermittent	• Cold Mill with Machine Patching • Hot Planing with Machine Patching • Machine Patching
	Frequent	• Rehabilitation Candidate
	Extensive	• Rehabilitation Candidate
	Throughout	• Rehabilitation Candidate

Deformation

Wheel Track Rutting

Description:

Longitudinal depressions, which can take the form of single rut or double ruts, left in the wheel tracks after repeated load application. Wheel track rutting results from densification and permanent deformation under the load, combined with displacement of pavement materials. Deep ruts are often accompanied by longitudinal cracking in the wheel tracks.

Possible Causes:

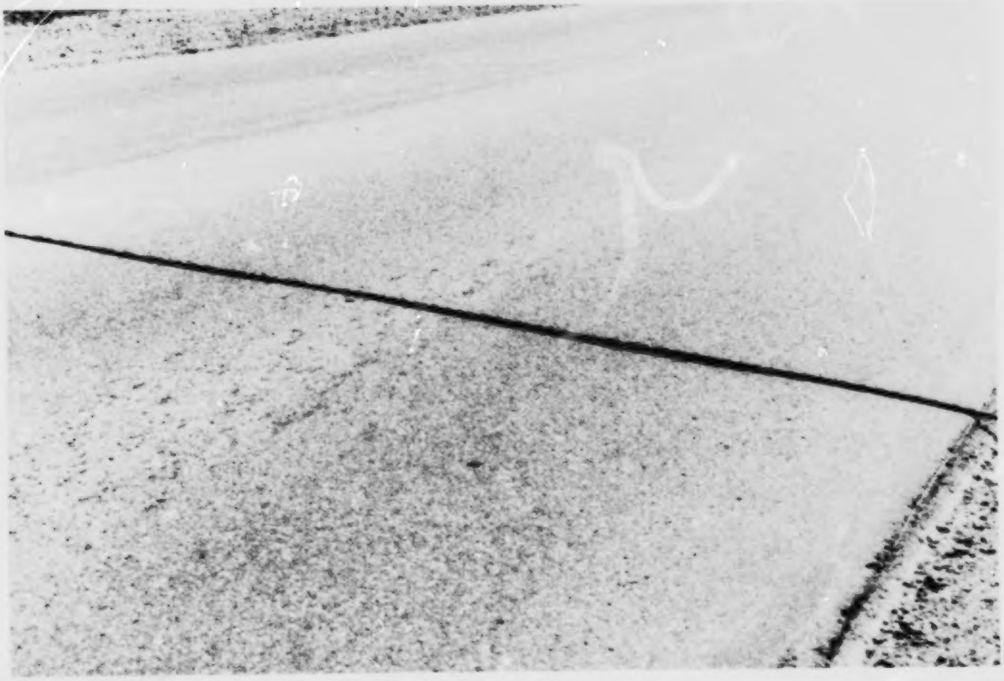
1. Poorly-compacted structural layers.
2. Unstable granular bases or subbases created by positive pore water pressures under loads at times of near-saturation.
3. Unstable asphalt mixes (due to high temperatures, high asphalt content, or low viscosity of binder).
4. Unstable shoulder material; does not provide adequate lateral support.
5. Overstressed subgrade will deform permanently.

Severity:

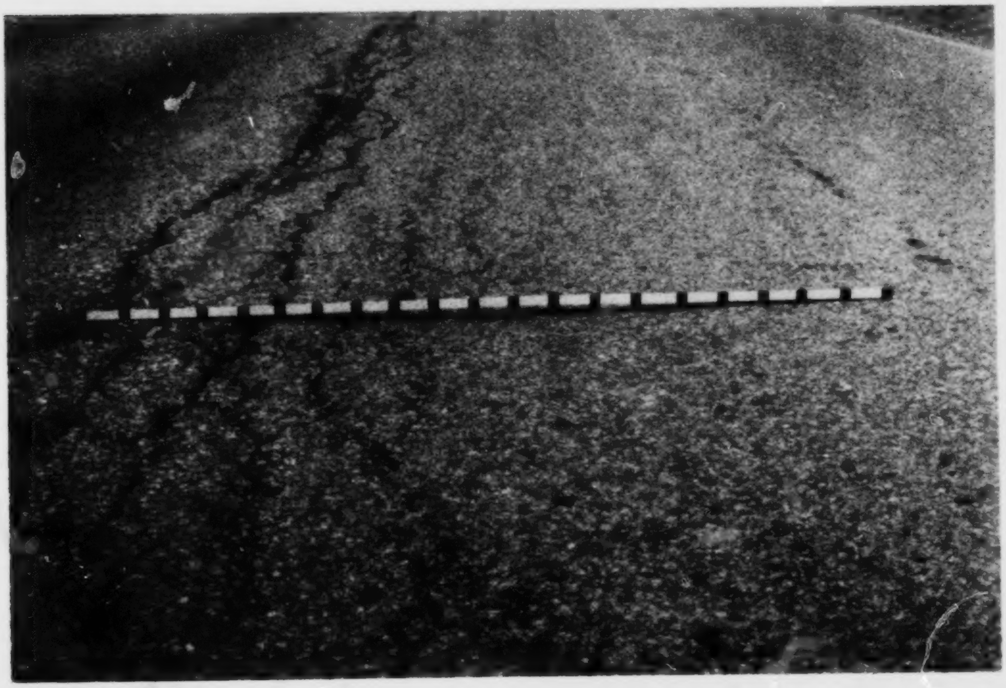
Class	Guidelines
Very slight	Barely noticeable, less than 6 mm (1.3 m baseline).
Slight	6 to 13 mm with or without single longitudinal crack.
Moderate	14 to 19 mm with or without single or multiple longitudinal cracks. Double rutting begins to develop.
Severe	20 to 90 mm with or without longitudinal cracks, or double rutting developed.
Very Severe	Greater than 50 mm single or double rutting with or without multiple longitudinal cracks or alligator cracks.

Density:

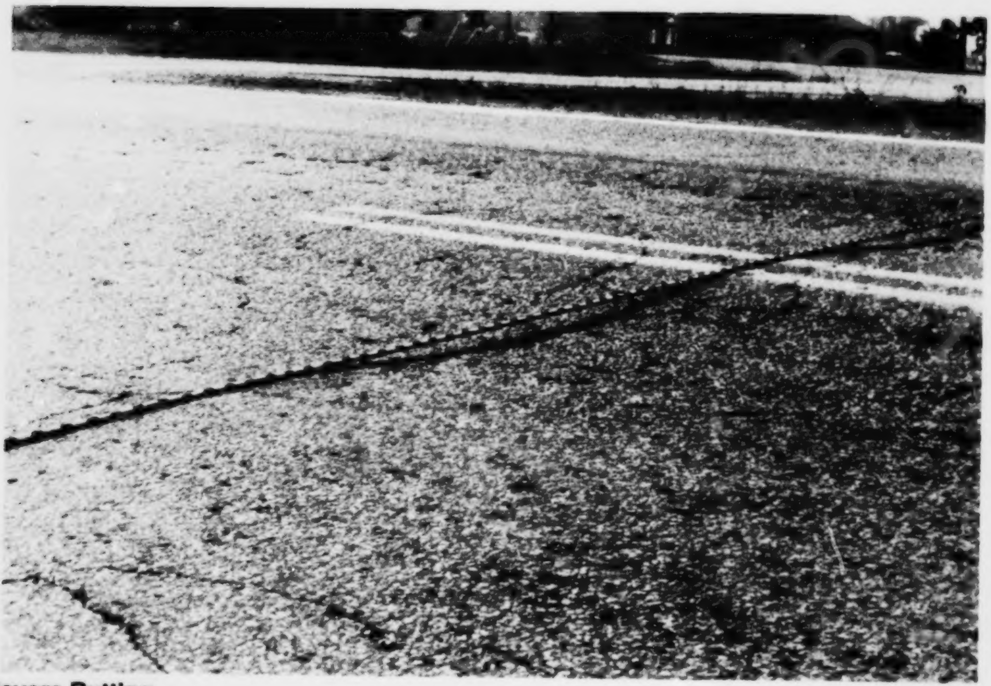
Class	Guidelines
Few	Less than 10% of wheel track affected.
Intermittent	10 to 20% of wheel track affected.
Frequent	20 to 50% of wheel track affected.
Extensive	50 to 80% of wheel track affected.
Throughout	80 to 100% of wheel track affected.



Slight Rutting



Moderate Rutting



Severe Rutting

Very Severe Rutting

Treatments

Evaluation		Suggested Remedial Measure Alternatives
Severity	Density	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Moderate	Few	• None
	Intermittent	• Machine Chip Seal • Machine Patching
	Frequent	• Machine Chip Seal • Machine Patching
	Extensive	• Machine Chip Seal • Machine Patching
	Throughout	• Machine Chip Seal • Machine Patching • Cold Mill with Hot-Mix Resurfacing
Severe	Few	• Machine Patching
	Intermittent	• Machine Patching
	Frequent	• Machine Patching
	Extensive	• Cold Mill with Hot-Mix Resurfacing • Hot-Mix Resurfacing
	Throughout	• Same alternatives as for "Extensive"
Very Severe	Few	• Machine Patching
	Intermittent	• Machine Patching
	Frequent	• Machine Patching
	Extensive	• Rehabilitation Candidate
	Throughout	• Rehabilitation Candidate

Distortion

Description:

Any deviation (other than described for rippling, shoving, and rutting) of the pavement surface from its original shape. Generally, distortions result from settlement slope failure, from volume changes due to moisture changes or frost heaving, and from residual effects of frost heaving accumulating after each winter.

Distortion may take the form of dishing, bumps, dips, tenting, or stepping at cracks, all of which give rise to pitch, roll, and jarring drop in a moving vehicle.

Possible Causes:

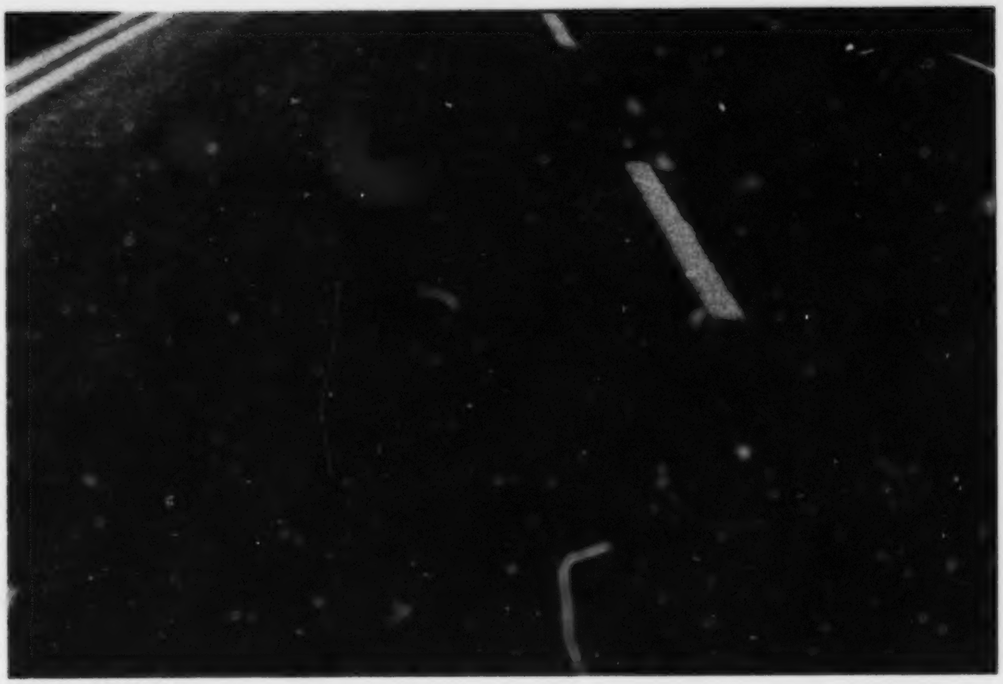
1. Differential frost heave in poorly-drained cuts and transitions.
2. Differential frost heave at pavement edges, road centre, or pavement cracks.
3. Reverse differential frost heave at culverts.
4. Differential settlement of subgrade or base material.
5. Lack of subgrade support.
6. Embankment slope failure.
7. Improper maintenance.

Severity:

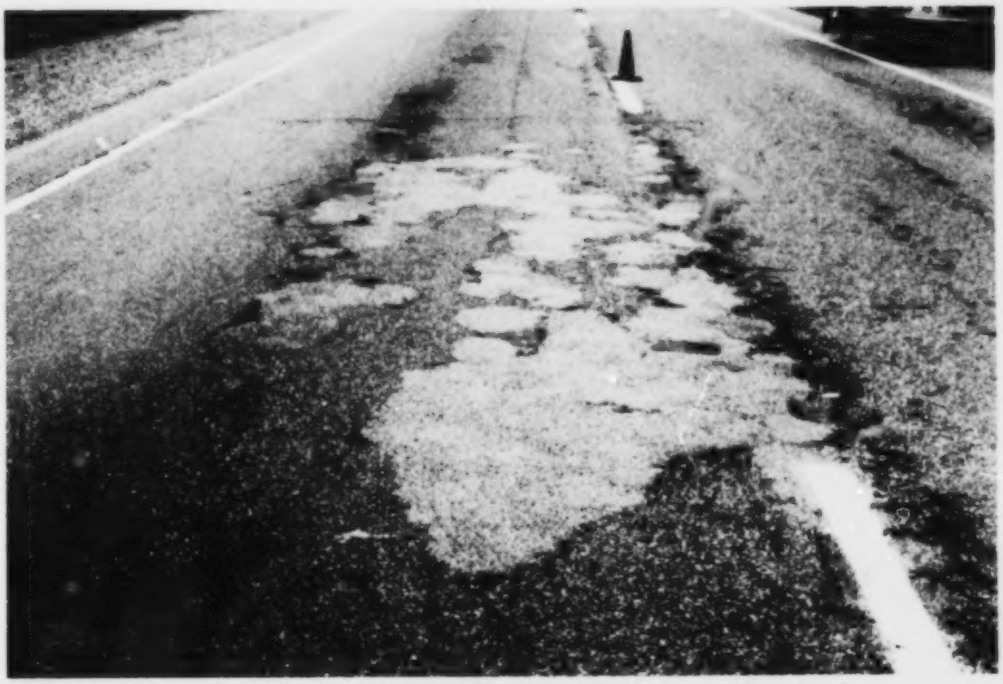
Class	Guidelines
Very slight	Barely noticeable swaying of vehicle while in motion.
Slight	Barely noticeable pitch and roll, and jarring bump or drop of vehicle while in motion.
Moderate	Noticeable pitch and roll, and harsh bump or jarring drop of vehicle while in motion.
Severe	Continuous pitch and roll, and hard jarring bump or drop of vehicle while in motion; driver always has to anticipate distortion ahead.
Very Severe	Continuous distortion, making the driver feel it is necessary to reduce speed from the posted speed.

Density:

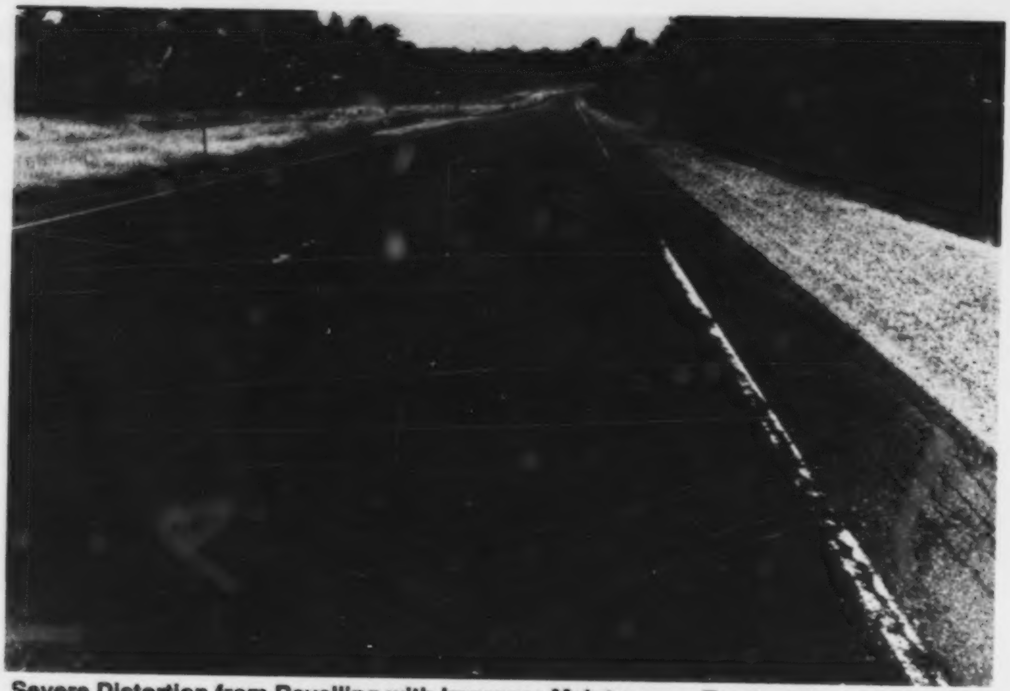
Class	Guidelines
Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavement section or over localized areas only.
Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.



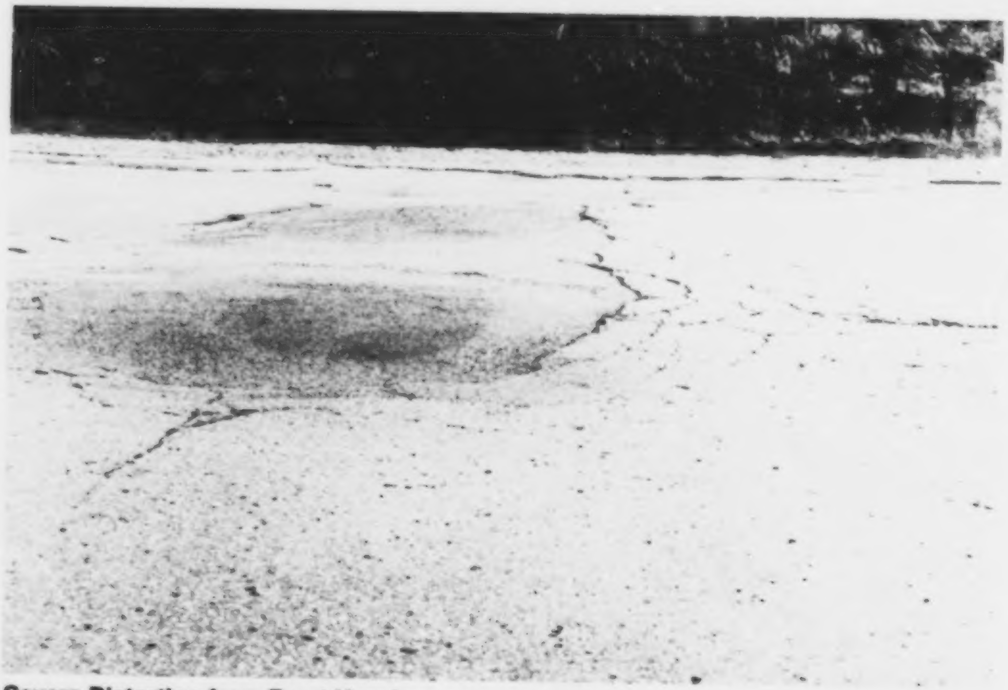
Slight Distortion



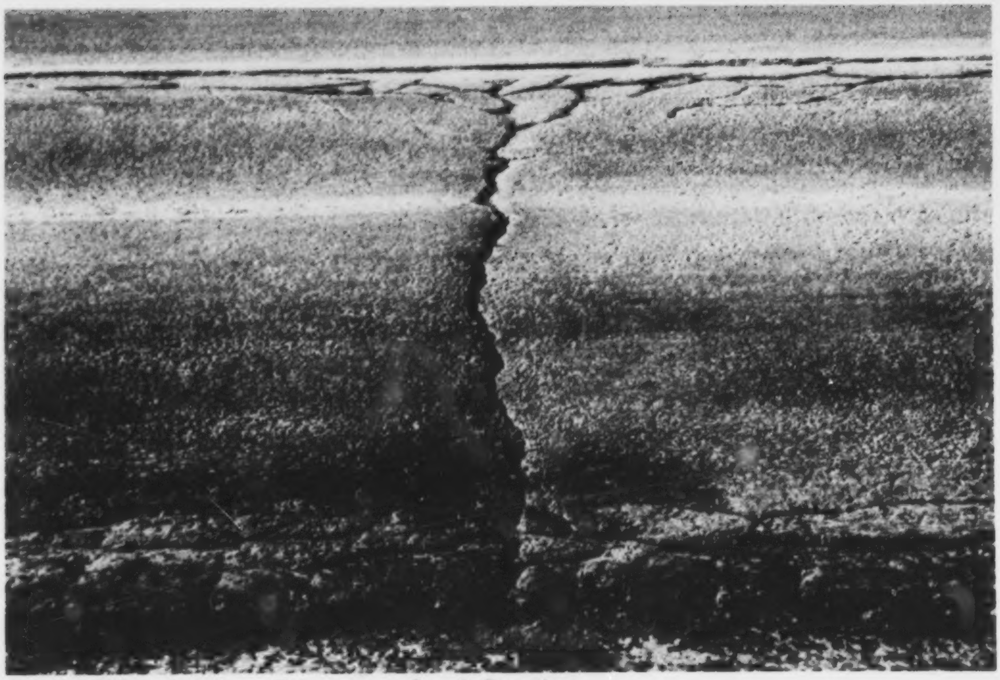
Moderate Distortion from Ravelling and Improper Maintenance Treatment



Severe Distortion from Ravelling with Improper Maintenance Treatment

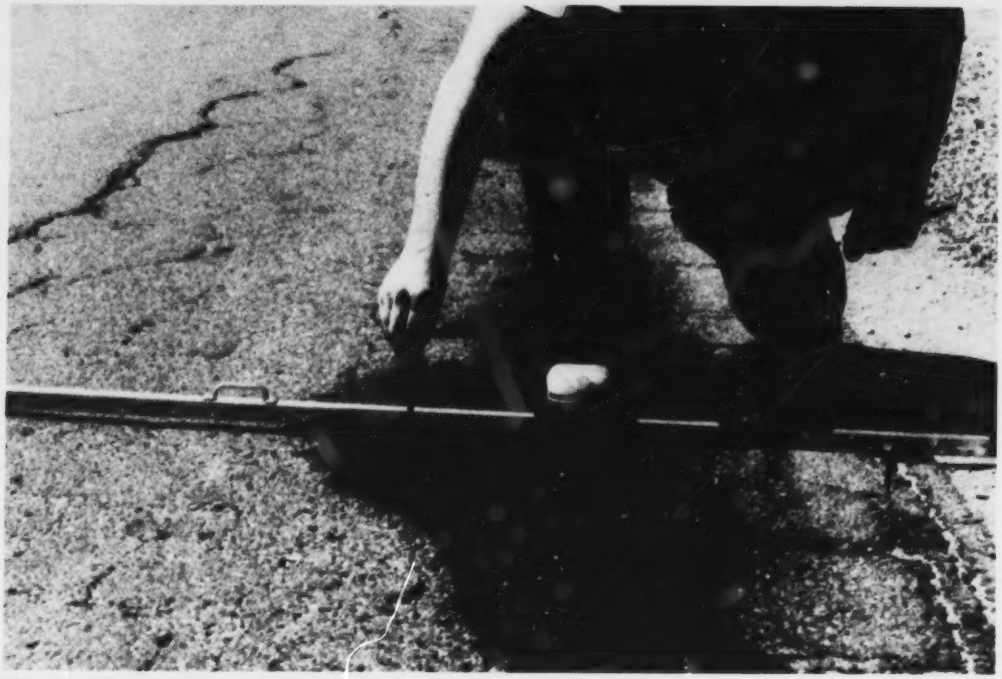


Severe Distortion from Frost Heaving



Severe Distortion from Transverse Crack Cupping

Very Severe Distortion from Transverse Crack Lipping



Severe Distortion from Lack of Structural Strength

Very Severe Distortion from Subgrade Failure

Treatments

Evaluation		Suggested Remedial Measure Alternatives
Severity	**Density**	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Moderate	Few	• None
	Intermittent	• Manual Patching • Machine Patching • Cold Mill or Hot Planing with Machine Patching
	Frequent	• Machine Patching • Cold Mill or Hot Planing with Machine Patching
	Extensive	• Machine Patching • Cold Mill or Hot Planing with Machine Patching
	Throughout	• Machine Patching • Cold Mill or Hot Planing with Machine Patching
Severe	Few	• Manual Patching • Machine Patching
	Intermittent	• Machine Patching • Cold Mill or Hot Planing with Machine Patching
	Frequent	• Machine Patching • Cold Mill or Hot Planing with Machine Patching
	Extensive	• Machine Patching • Cold Mill or Hot Planing with Machine Patching • Machine Patching • Hot-Mix Resurfacing
	Throughout	• Cold Mill or Hot Planing with Machine Patching • Hot-Mix Resurfacing
Very Severe	Few	• Manual Patching • Machine Patching
	Intermittent	• Machine Patching • Cold Mill or Hot Planing with Machine Patching
	Frequent	• Rehabilitation Candidate
	Extensive	• Rehabilitation Candidate
	Throughout	• Rehabilitation Candidate

5.3/ Cracking

Longitudinal Wheel-Track Cracking

Longitudinal Meander and Mid-Lane Crack

Centre Line Crack

Pavement Edge Crack

Transverse Crack

Map Crack

Alligator Cracking

Longitudinal Wheel-Track Cracking

Description: Cracks which follow a course approximately parallel to the centre line of the pavement and are situated at or near the centre of the wheel tracks.

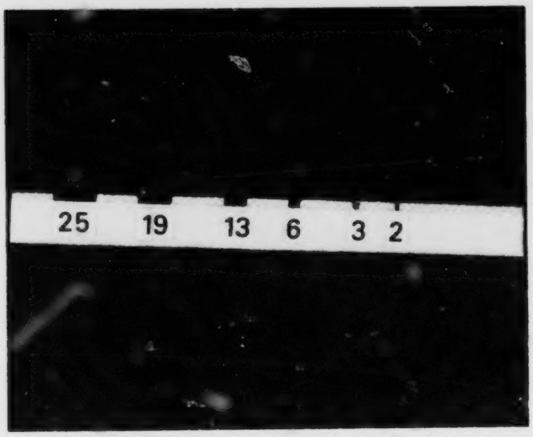
Possible Causes: Overloaded vehicles at the weakest pavement period, in the early spring. Fatigue failure of thin asphalt surfacings is initiated in this manner.

Severity:

Class	Guidelines
Very Slight	Single crack less than 3 mm.
Slight	Single crack from 3 mm to 12 mm.
Moderate	Single or multiple cracks. Single crack from 13 mm to 19 mm. Multiple cracks even if less than 13 mm.
Severe	Single or multiple cracks. Single crack 20 mm to 25 mm, with initial sign of spalling. Multiple cracks even if less than 20 mm but greater than 13 mm, with initial sign of spalling.
Very Severe	Single or multiple cracks. Single crack greater than 25 mm, with or without spalling. Multiple cracks even if less that 25 mm but greater than 20 mm, with or without spalling.

Density:

Class	Guidelines
Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavement section or over localized areas only.
Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.



Very Slight Crack (less than 3 mm)

Slight Crack (3 mm)

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NORTH GOWER
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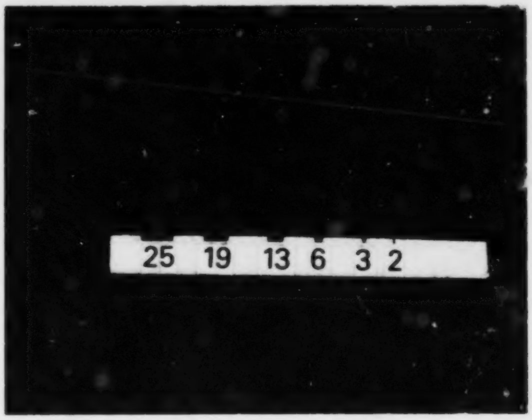
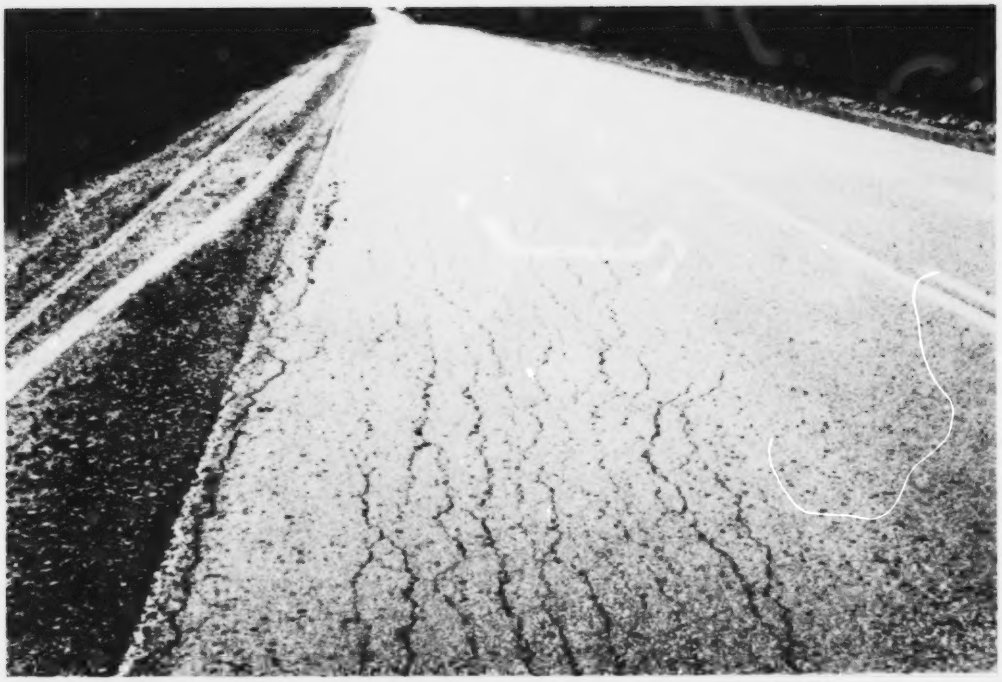
Moderate (Multiple) Longitudinal Wheel Track Crack

Moderate Crack (Single 13 mm to19 mm)



Severe Crack (Single 20 mm to 25 mm)



Severe Longitudinal Outer Wheel Track Crack Progresses Into Moderate Alligator Crack

Treatments

Evaluation		Suggested Remedial Measure Alternatives
Severity	**Density**	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Slight	Few	• None
	Intermittent	• Rout and seal if pavement is composite type (asphalt over concrete or soil cement base). Rout and seal if crack is greater than 6 mm and pavement is asphalt only.
	Frequent	• Same as above
	Extensive	• Same as above
	Throughout	• Same as above
Moderate	Few	• Rout and seal if crack is single, or if cracks are multiple with minor amount of multiple cracking.
	Intermittent	• Same as above
	Frequent	• Same as above
	Extensive	• Same as above
	Throughout	• Same as above
Severe	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• Rehabilitation Candidate
	Throughout	• Same as above
Very Severe	Few	• None
	Intermittent	• None
	Frequent	• Rehabilitation Candidate
	Extensive	• Same as above
	Throughout	• Same as above

Longitudinal Meander and Mid-Lane Crack

Description:

Crack, usually quite long, which wanders from edge to edge of the pavement, or crack which is usually straight and parallel to the centre line, at or near the middle of the lane. These types of cracks are usually single cracks, but occasionally secondary cracks do develop parallel to them.

Possible Causes:

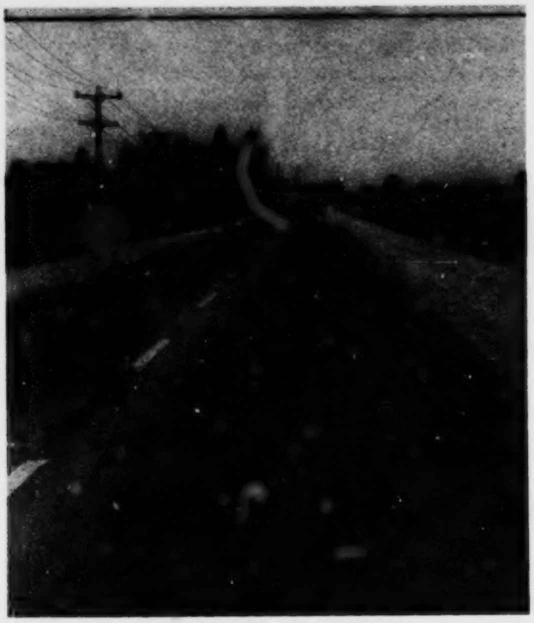
1. Frost action — greater heave at pavement centre than at edges. More prevalent in mixes where asphalt stripping is extensive.
2. Poor construction practices.
3. Faulty construction equipment, resulting in weak plane which then fails, due to thermal shrinkage.

Severity:

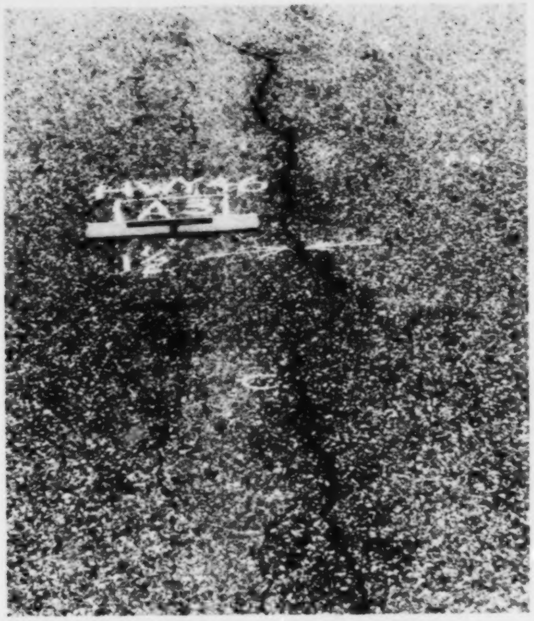
Class	Guidelines
Very Slight	Single crack less than 3 mm.
Slight	Single crack from 3 mm to 12 mm.
Moderate	Single or multiple cracks. Single crack from 13 mm to 19 mm. Multiple cracks even if less than 13 mm.
Severe	Single or multiple cracks. Single crack 20 mm to 25 mm, with initial sign of spalling. Multiple cracks even if less than 20 mm but greater than 13 mm, with initial sign of spalling.
Very Severe	Single or multiple cracks. Single crack greater than 25 mm, with or without spalling. Multiple cracks even if less than 25 mm but greater than 20 mm, with or without spalling.

Density:

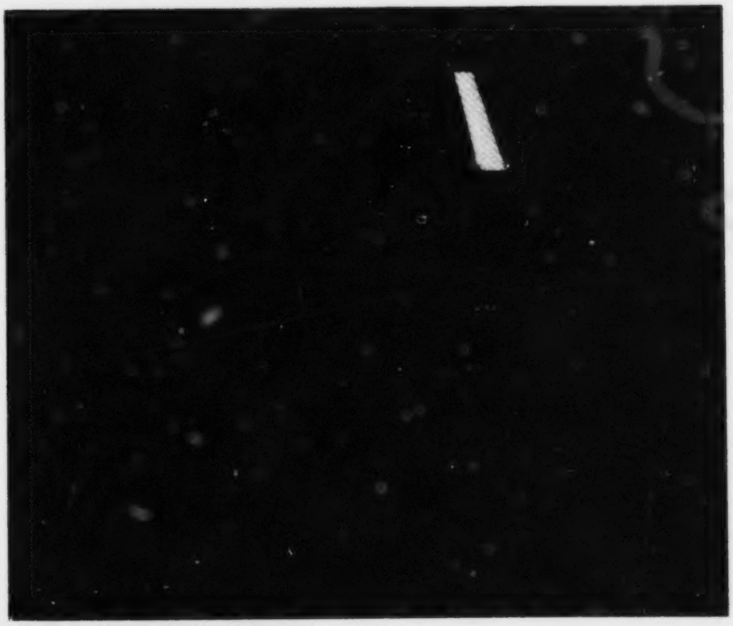
Class	Guidelines
Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavement section or over localized areas only.
Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.



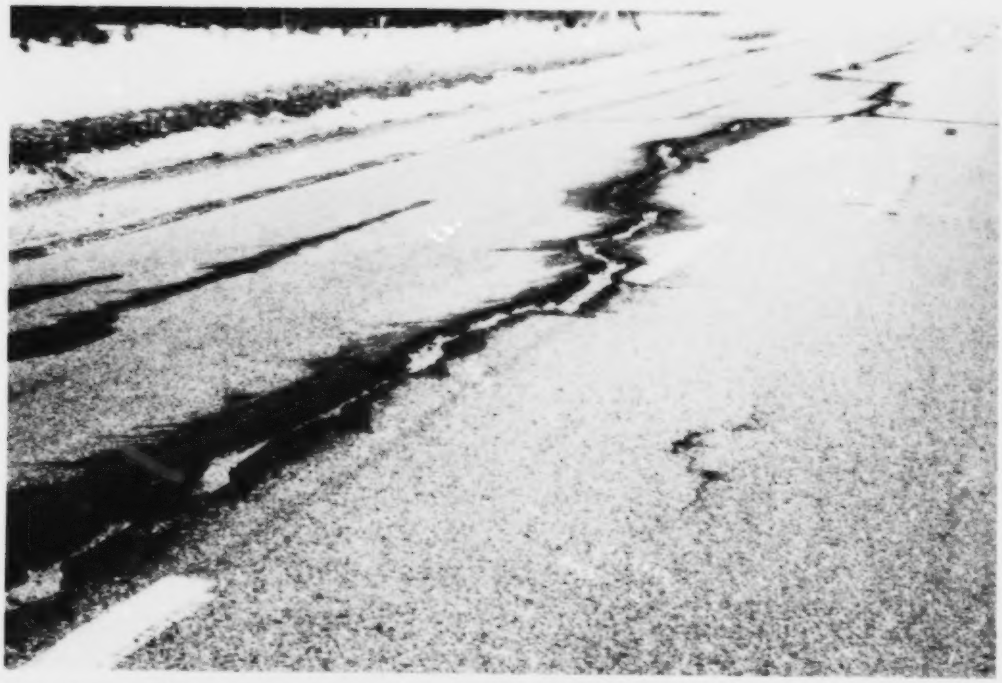
Slight Longitudinal Mid-lane Crack



Moderate (Multiple) Longitudinal Mid-lane Crack



Severe Meandering Crack



Very Severe Meandering Crack (Single greater than 25 mm)

Treatments

Evaluation		Suggested Remedial Measure Alternatives
Severity	**Density**	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Slight	Few	• None
	Intermittent	• Rout and seal if pavement is composite type (asphalt over concrete or soil cement base). Rout and seal if crack is greater than 6 mm and pavement is asphalt only.
	Frequent	• Same as above
	Extensive	• Same as above
	Throughout	• Same as above
Moderate	Few	• Rout and seal if crack is single, or if cracks are multiple with minor amount of multiple cracking.
	Intermittent	• Same as above
	Frequent	• Same as above
	Extensive	• Same as above
	Throughout	• Same as above
Severe	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• Rehabilitation Candidate
	Throughout	• Same as above
Very Severe	Few	• None
	Intermittent	• None
	Frequent	• Rehabilitation Candidate
	Extensive	• Same as above
	Throughout	• Same as above

Centre Line Crack

Description: Crack(s) which run(s) along or near the road centre line.

Possible Causes:

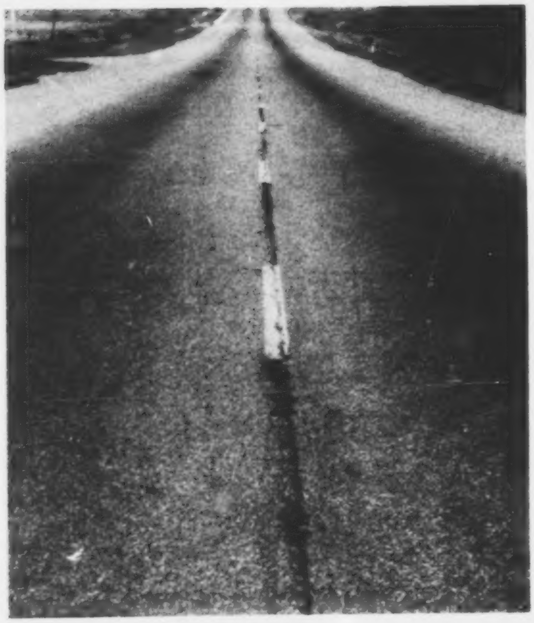
1. Poor longitudinal joint construction.
2. Frost action–variable granular depths due to constructing lanes separately; differential frost heave along centre line due to insulating value of snow along pavement edges.
3. Moisture changes (swelling/shrinkage).

Severity:

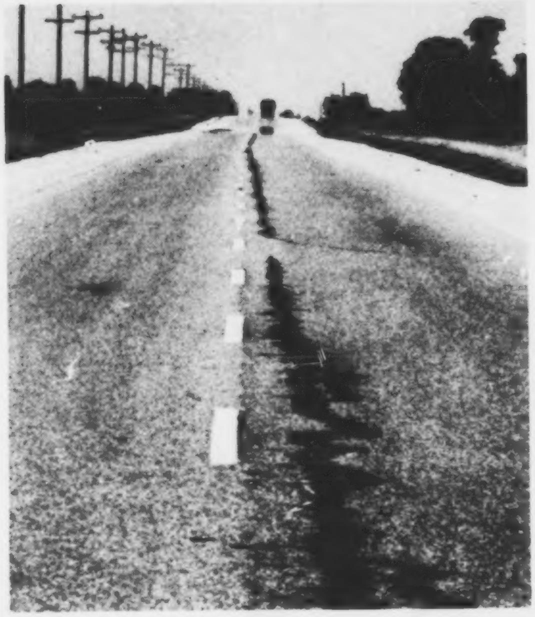
Class	Guidelines
Very Slight	Single crack less than 3 mm.
Slight	Single crack from 3 mm to 12 mm.
Moderate	Single or multiple cracks. Single crack from 13 mm to 19 mm. Multiple cracks even if less than 13 mm.
Severe	Single or multiple cracks. Single crack 20 mm to 25 mm, with initial sign of spalling. Multiple cracks even if less than 20 mm but greater than 13 mm, with initial sign of spalling.
Very Severe	Single or multiple cracks. Single crack greater than 25 mm, with or without spalling. Multiple cracks even if less than 25 mm but greater than 20 mm, with or without spalling.

Density:

Class	Guidelines
Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavement section or over localized areas only.
Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.

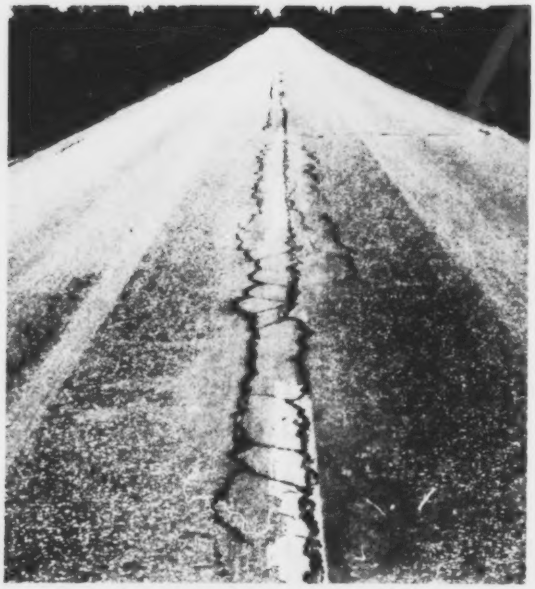


Slight Centre Line Crack

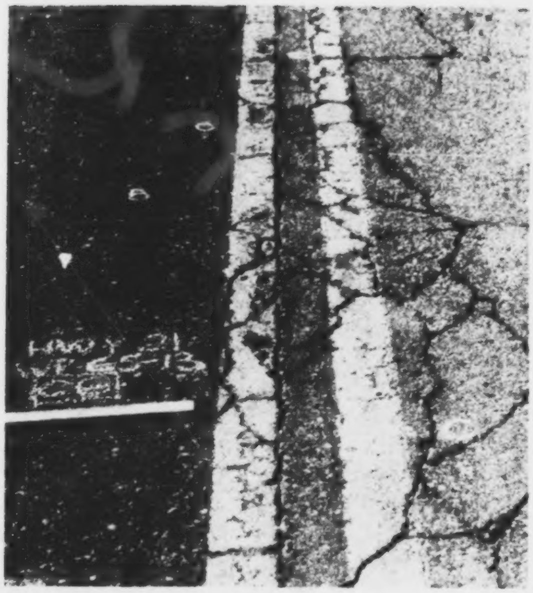


Moderate Centre Line Crack

Moderate (Multiple) Centre Line Crack



Severe (Multiple) Centre Line Crack



Severe Centre Line Crack

Treatments

Evaluation		Suggested Remedial Measure Alternatives
Severity	**Density**	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Slight	Few	• None
	Intermittent	• Rout and seal if pavement is composite type (asphalt over concrete or soil cement base. Rout and seal if crack is greater than 6 mm and pavement is asphalt only.
	Frequent	• Same as above
	Extensive	• Same as above
	Throughout	• Same as above
Moderate	Few	• Rout and seal if crack is single, or if cracks are multiple with minor amount of multiple cracking.
	Intermittent	• Same as above
	Frequent	• Same as above
	Extensive	• Same as above
	Throughout	• Same as above
Severe	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• Rehabilitation Candidate
	Throughout	• Same as above
Very Severe	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• Rehabilitation Candidate
	Throughout	• Same as above

Pavement Edge Crack

Description:

Crack (or cracks) which is parallel to and within 30 cm of the pavement edge, and is either a fairly continuous "straight" crack or consists of crescent-shaped cracks in a wave formation. On some thin asphalt surfaces, pavement edge cracking progressively encroaches onto the outerwheel tracks through the middle of the lane, and may even progress right across to the centre line.

Possible Causes:

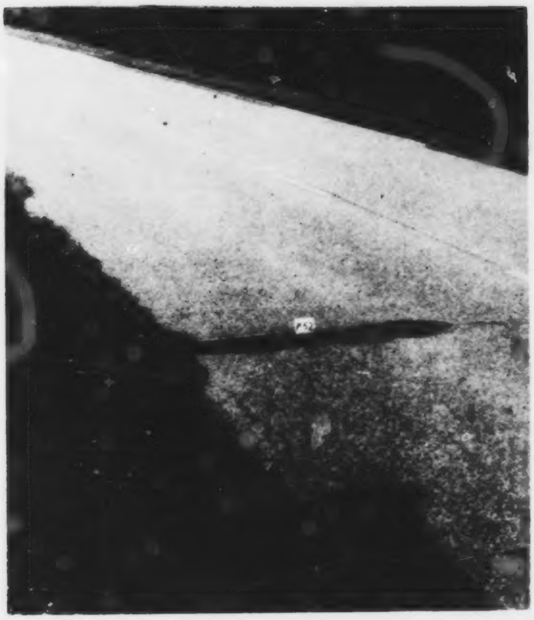
1. Frost action.
2. Insufficient bearing support and/or excessive traffic loading at the pavement edge.
3. Poor drainage at pavement edge and shoulder.
4. Inadequate pavement width forces traffic too close to pavement edge.

Severity:

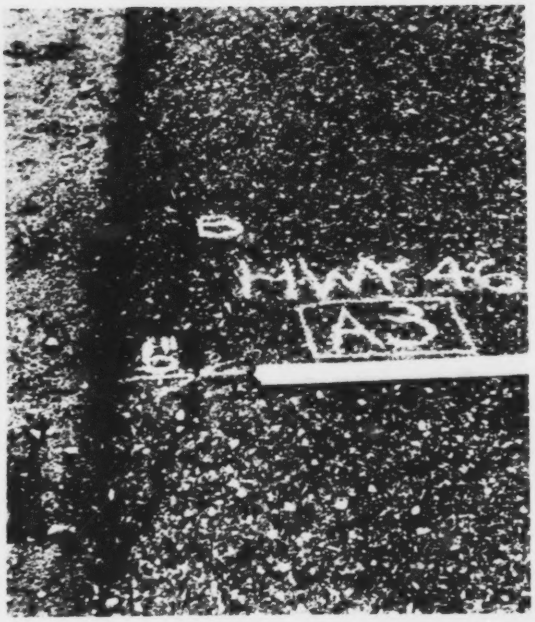
Class	Guidelines
Very Slight	Single longitudinal crack or single wave-formation crack less than 3 mm wide and no more than 150 mm from pavement edge.
Slight	Single crack or two parallel cracks 3 mm to 12 mm wide and less than 300 mm from pavement edge.
Moderate	Extending over 300 mm but less than 600 mm from pavement edge. Multiple cracks begin to interweave with connecting cracks.
Severe	Extending over 600 mm but under 1500 mm from pavement edge. Outermost area near edge cracks begins to develop connecting cracks to give appearance of alligatoring.
Very Severe	Progressive multiple cracks extend over 1500 mm from pavement edge. Outermost area near edge is alligatored.

Density:

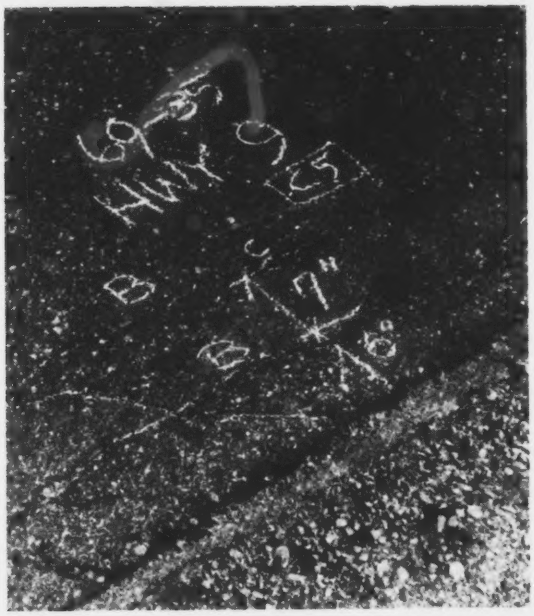
Class	Guidelines
Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
Frequent	20 to 50% of pavement surface affected. May be spotted evenly over length of pavement section or over localized areas only.
Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.



Very Slight Pavement Edge Crack



Slight Pavement Edge Crack (Wave Formation)



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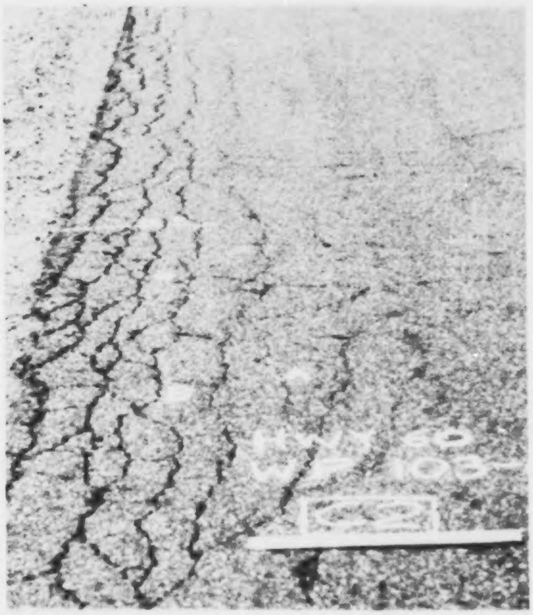
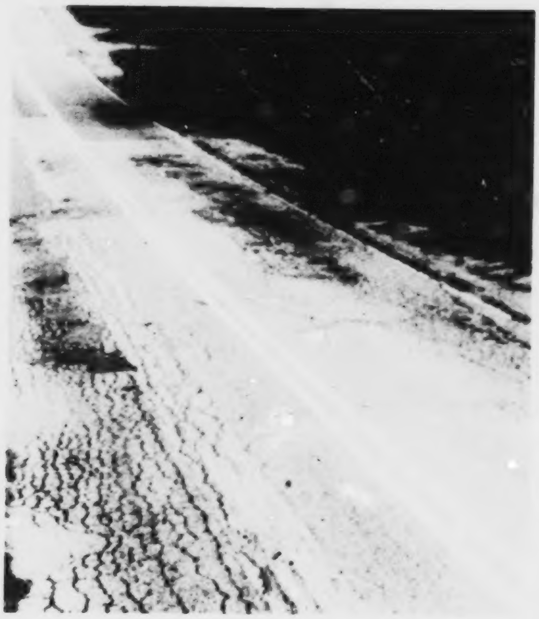
Moderate (Multiple) Pavement Edge Crack



Severe (Multiple) Pavement Edge Crack



Very Severe Pavement Edge Crack

Treatments

Evaluation		Suggested Remedial Measure Alternatives
Severity	**Density**	
Very Slight	Few	None
	Intermittent	None
	Frequent	None
	Extensive	None
	Throughout	None
Slight	Few	None
	Intermittent	Rout and seal
	Frequent	Rout and seal
	Extensive	Rout and seal
	Throughout	Rout and seal
Moderate	Few	None
	Intermittent	None
	Frequent	Manual Chip Seal
	Extensive	Manual Chip Seal
	Throughout	Manual Chip Seal
Severe	Few	None
	Intermittent	Manual Chip Seal
	Frequent	Manual Chip Seal
	Extensive	Manual Chip Seal
	Throughout	None
Very Severe	Few	None
	Intermittent	None
	Frequent	None
	Extensive	Rehabilitation Candidate
	Throughout	Rehabilitation Candidate

Transverse Crack

Description:

Crack which follows a course approximately at right angles to the pavement centre line. Full transverse cracks tend to be regularly spaced along the length of the road, while half transverse and part transverse occur at shorter, intermediate distances.

Possible Causes:

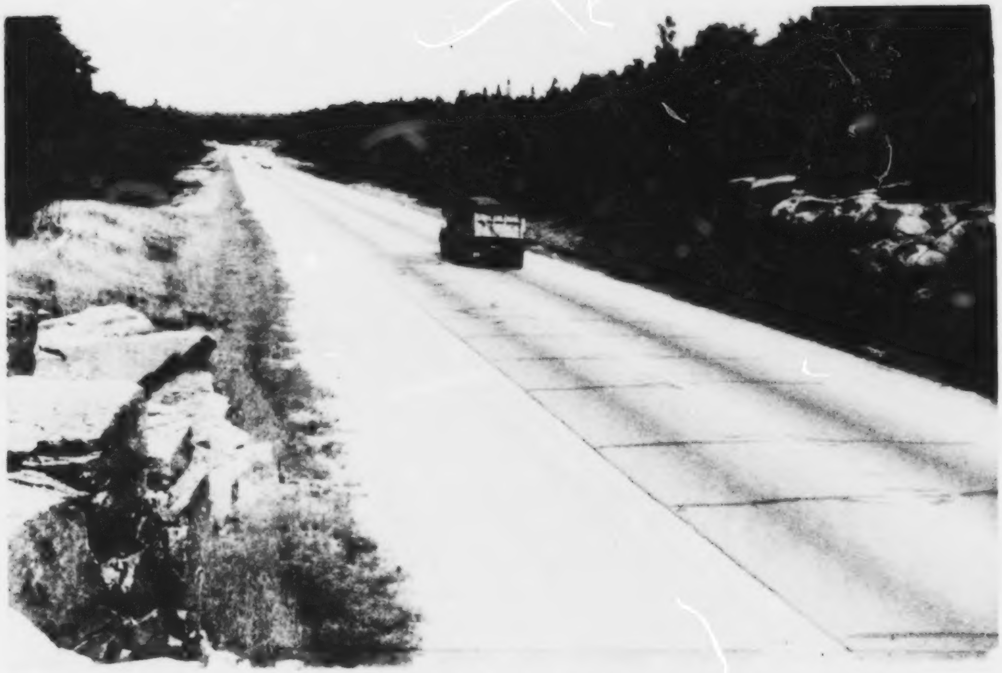
1. Natural shrinkage caused by very low temperatures.
2. High temperature susceptibility of asphalt cement binder in asphalt mixes.
3. Frost action.
4. Reflection cracks.

Severity:

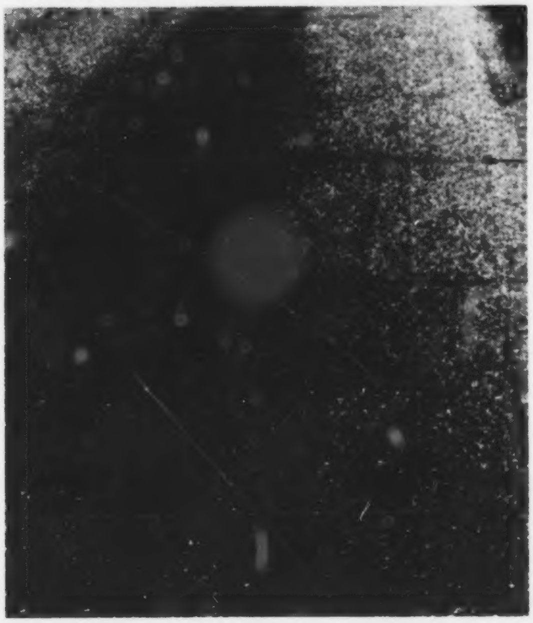
Class	Guidelines
Very Slight	Less than 3 mm single crack.
Slight	Single crack 3 mm to 12 mm.
Moderate	13 mm to 19 mm single crack, or multiple cracks even if crack opening is less than 13 mm. Cracks starting to develop cupping or lipping.
Severe	20 mm to 25 mm single crack, or multiple cracks even if crack opening is less than 20 mm but greater than 13 mm. Cracks have developed cupping or lipping distortion.
Very Severe	Greater than 25 mm single crack, or multiple cracks even if crack opening is less than 25 mm but greater than 20 mm. Cracks are distorted with cupping and lipping, and spalling of the cracked edges.

Density:

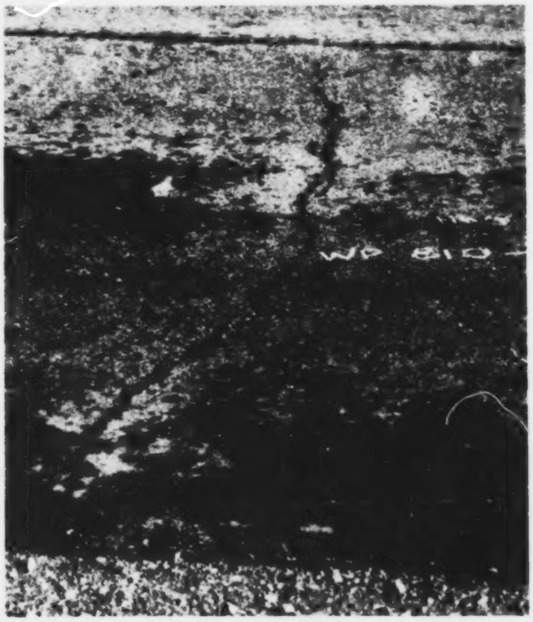
Class	Guidelines
Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavement section or over localized areas only.
Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.



Typical Transverse Crack Regularly Spaced along the Length of the Roadway

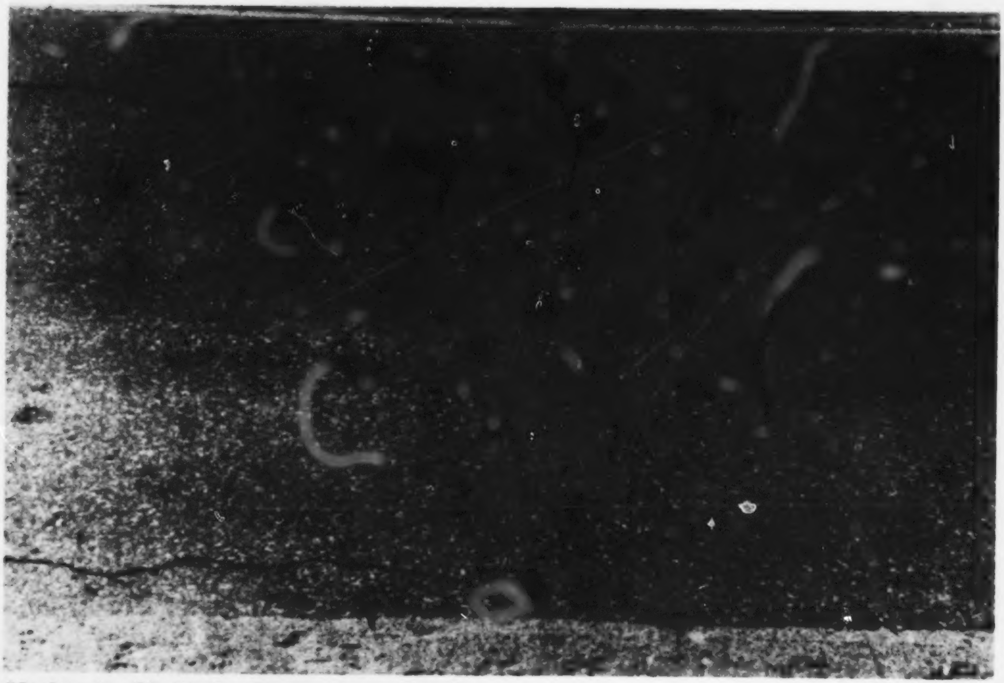


Very Slight Partial Transverse Crack

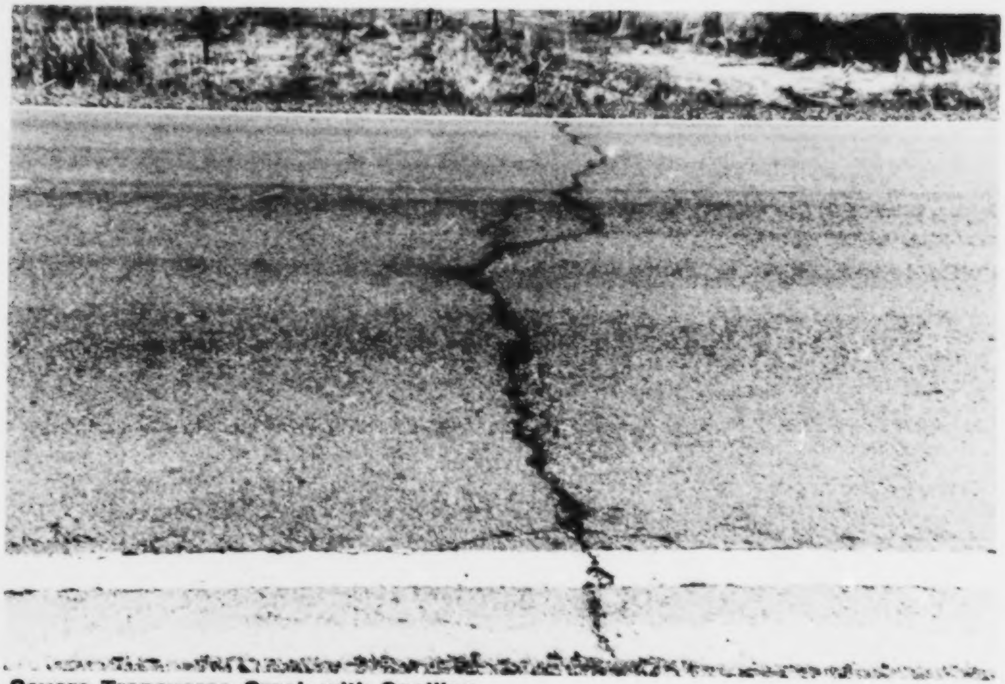


Slight Half Transverse Crack

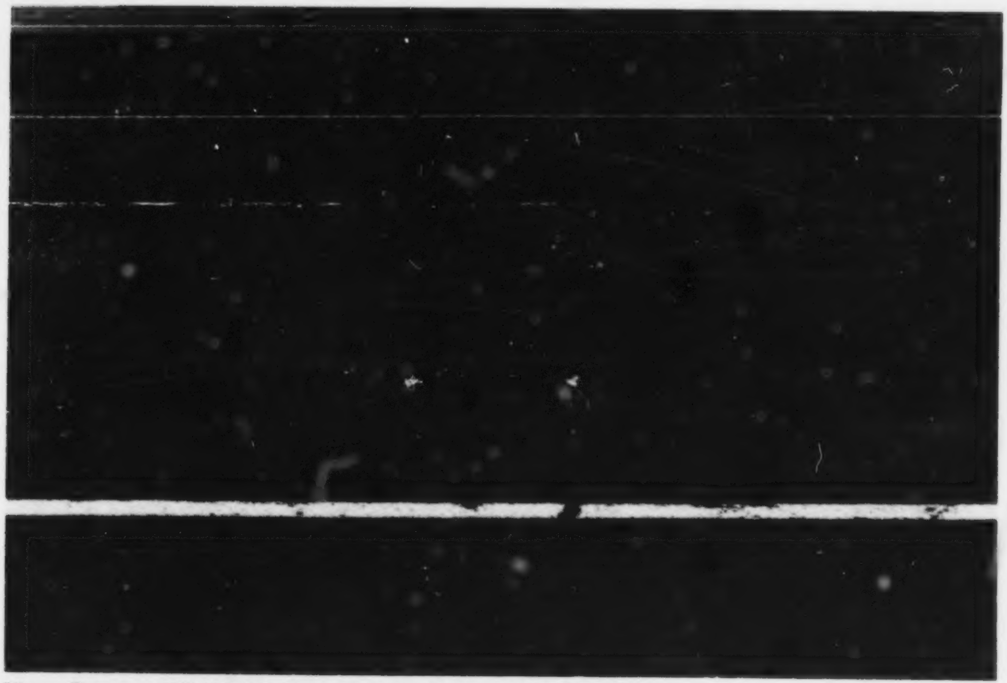
Moderate Transverse Crack



Moderate (Multiple) Transverse Crack



Severe Transverse Crack with Spalling



Very Severe (Multiple) Transverse Crack with Spalling

Treatments

Evaluation		Suggested Remedial Measure Alternatives
Severity	**Density**	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• Rout and seal if pavement is composite type.
	Extensive	• Same as above
	Throughout	• Same as above
Slight	Few	• None
	Intermittent	• Rout and seal
	Frequent	• Rout and seal
	Extensive	• Rout and seal
	Throughout	• Rout and seal
Moderate	Few	• None
	Intermittent	• Rout and seal
	Frequent	• Rout and seal
	Extensive	• Rout and seal
	Throughout	• Rout and seal
		• None, but consider for rehabilitation.
Severe	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• Rehabilitation Candidate
	Throughout	• Rehabilitation Candidate
Very Severe	Few	• None
	Intermittent	• None
	Frequent	• Rehabilitation Candidate
	Extensive	• Rehabilitation Candidate
	Throughout	• Rehabilitation Candidate

Map Crack

Description:

Interconnected cracks forming a series of large polygons which resemble a map. The cracking appears to combine transverse and longitudinal cracks. This form of distress is also called random cracking.

Possible Causes:

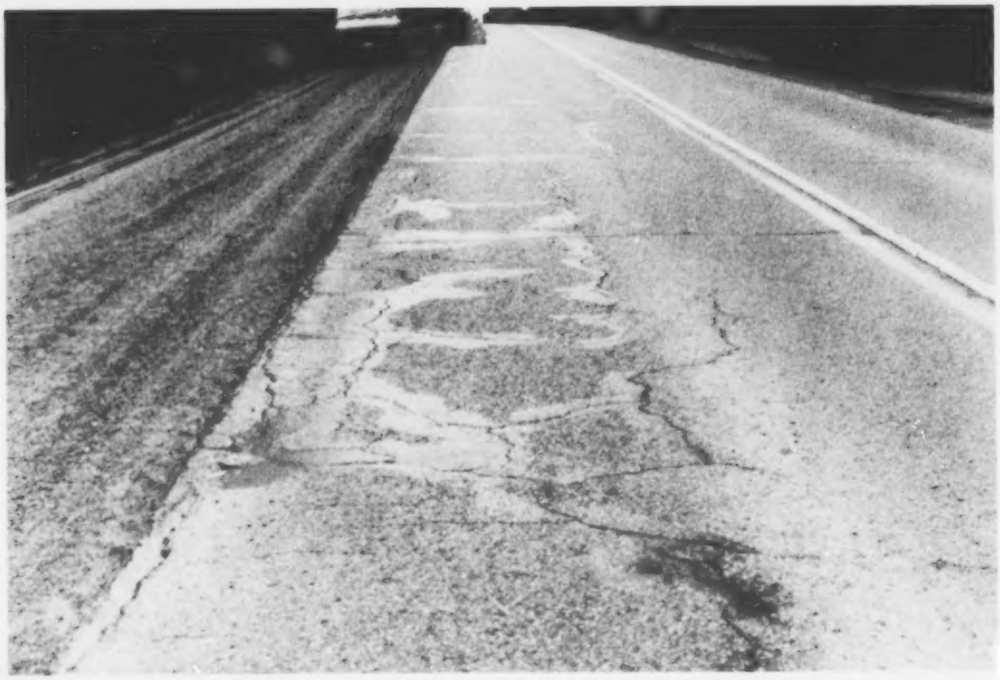
1. Swelling or shrinkage.
2. Frost action.
3. Hardening and shrinkage of the asphalt due to age.

Severity:

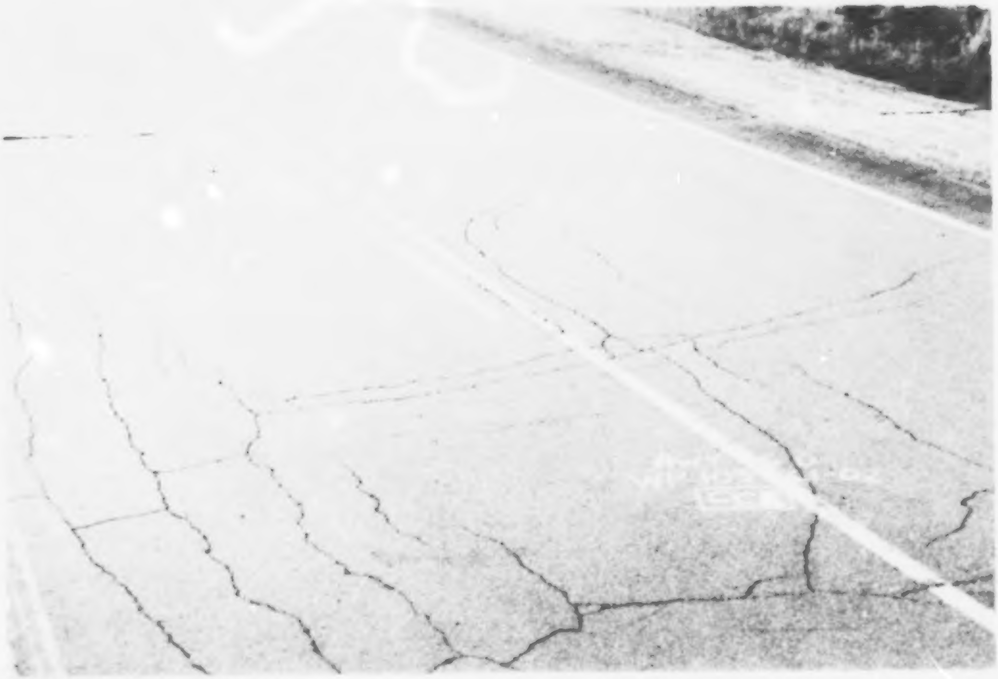
Class	Guidelines
Very Slight	Single cracks less than 3 mm and of short length, developed randomly between transverse cracks.
Slight	Single cracks 3 mm to 12 mm, well spaced but interconnected to form map-like appearance between transverse cracks.
Moderate	Interconnected cracks begin to develop multiple cracks. First sign of spalling. Single crack width 13 mm to 19 mm.
Severe	Multiple interconnected cracks, some with spalling. Single crack width 20 mm to 25 mm.
Very Severe	Multiple interconnected cracks, many with spalling or even potholes. Single cracks width more than 25 mm.

Density:

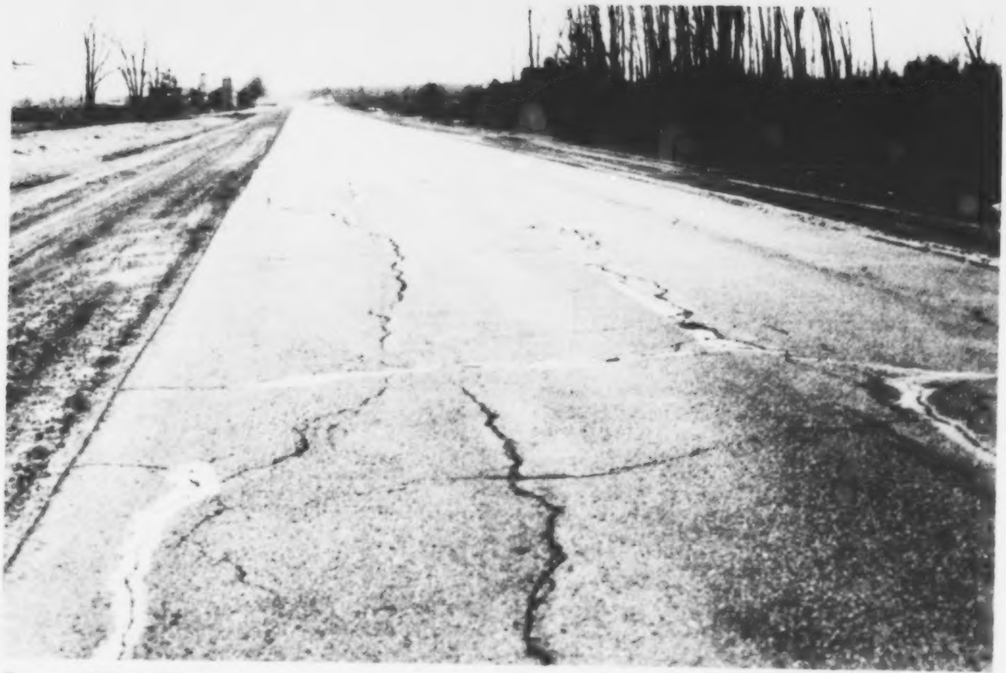
Class	Guidelines
Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavements section or over localized areas only.
Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.



Slight Map Crack



Moderate Map Crack



Severe Map Crack

Treatment

Evaluation		Suggested Remedial Measure Alternatives
Severity	Density	
Very Slight	Few	None
	Intermittent	None
	Frequent	None
	Extensive	None
	Throughout	None
Slight	Few	None
	Intermittent	None
	Frequent	None
	Extensive	None
	Throughout	None
Moderate	Few	None
	Intermittent	None
	Frequent	None
	Extensive	Rehabilitation Candidate
	Throughout	Rehabilitation Candidate
Severe	Few	Manual Chip Seal
	Intermittent	Manual Chip Seal Machine Chip Seal Machine Patching
	Frequent	Machine Chip Seal Machine Patching Rehabilitation Candidate
	Extensive	Machine Chip Seal Machine Patching Rehabilitation Candidate
	Throughout	Rehabilitation Candidate
Severe	Few	Manual Chip Seal Machine Patching
	Intermittent	Same as above
	Frequent	Rehabilitation Candidate
	Extensive	Rehabilitation Candidate
	Throughout	Rehabilitation Candidate

Alligator Crack

Description:

Cracks which form a network of polygon blocks resembling the skin of an alligator. The block size, which can range from a few millimetres to about a metre, is indicative of the level (depth) at which failure is taking place. Small block sizes (100 mm to 150 mm) indicate that movement is occurring in the upper (granular base) layer. This type of alligatoring is mostly observed on "thin" (less than 75 mm) asphalt surfacings, accompanied at times by slight depressions (perhaps 12 mm). Large block sizes (300 mm and more) indicate that movement is occurring in the deep granular layers and subgrade. This type of alligatoring is accompanied by large depressions (perhaps as much as 50 mm), together with lateral movement of the pavement edge outwards (and upwards); the pavement forms a "bird-bath" during rains.

Alligator cracking is a consequence of the inability of a part of the structure to support the repeated loads, due to a "softening" of the underlying material. Softening is normally associated with an increase in moisture content. Cracks such as transverse, centre line, and longitudinal, which are left unsealed, will allow surface water to infiltrate the pavement structure and cause softening. Alligatoring will be the final stage of crack development.

Alligator-type failures which are deep-seated in the subbase or subgrade are progressive (that is, under traffic and rains they tend to spread rapidly) and traffic causes blocks of surfacing to be displaced and broken up. The only successful remedial treatment is to remove all softened material in the affected area and replace it with sound materials.

Alligator failures in the upper layers normally appear in the very early spring. They do not generally progress after warmer weather appears, probably because drainage of the wet granular bases has increased pavement strength.

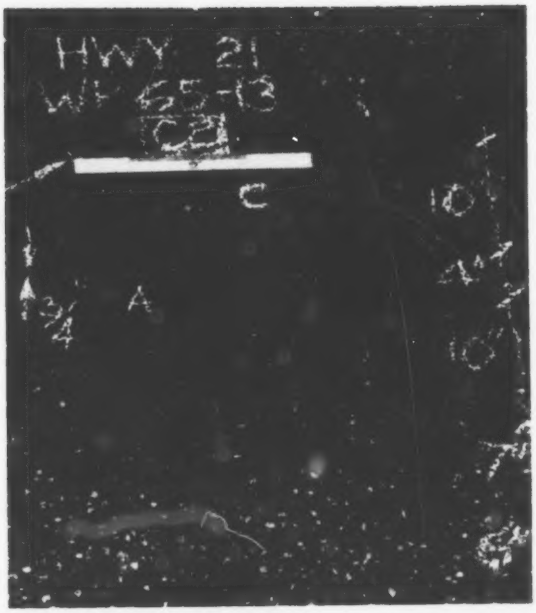
Possible Causes:

1. Insufficient bearing support.
2. Poor base drainage, and stiff or brittle asphalt mixes at cold temperatures.

Severity:

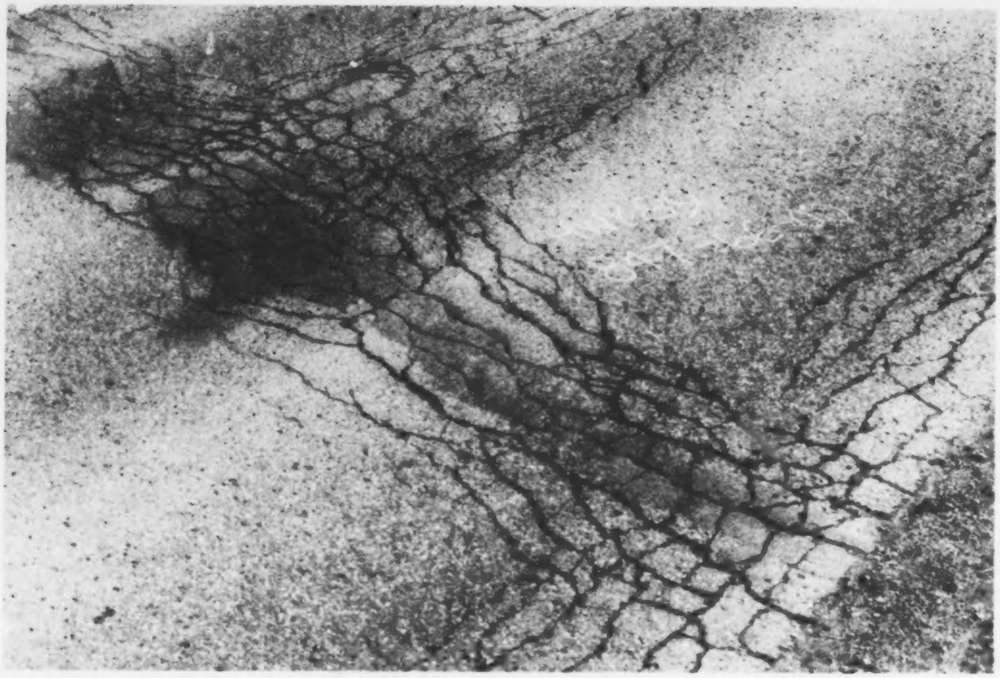
Class	Guidelines
Very Slight	Multiple cracks begin to develop short interconnecting cracks. Distortion less than 13 mm.
Slight	Alligator pattern established with corners of polygon blocks fracturing. Distortion less than 13 mm.
Moderate	Alligator pattern established with spalling of polygon blocks. Distortion 13 mm to 25 mm.
Severe	Polygon blocks begin to lift. Small potholes. Distortion 26 mm to 50 mm.
Very Severe	Polygon blocks lifting, with different sizes of potholes. Distortion greater than 50 mm.

Density:	**Class**	**Guidelines**
	Few	Less than 10% of pavement surface affected. Spotted over localized areas only.
	Intermittent	10 to 20% of pavement surface affected. Spotted over localized areas only.
	Frequent	20 to 50% of pavement surface affected. May spot evenly over length of pavement section or over localized areas only.
	Extensive	50 to 80% of pavement surface affected. Spotted evenly over length of pavement section.
	Throughout	80 to 100% of pavement surface affected. Spotted evenly over length of pavement section.



Very Slight Alligator Crack
(Pavement Edge Crack)

Slight Alligator Crack
(Wheel Track Longitudinal Crack)



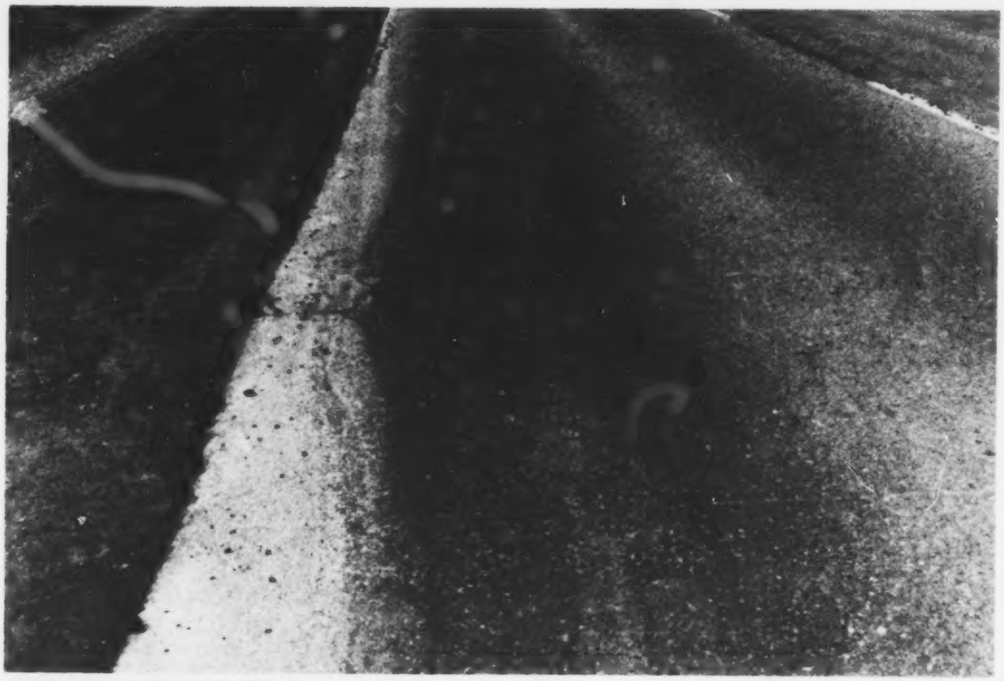
Moderate Alligator Crack (Transverse Crack)

[Result of movement occurring in the upper (granular base) layer]

Severe Alligator Crack *

Very Severe Alligator Crack *

(* Result of movement occurring in the deeper layers and subgrade)



Moderate Alligator Crack

(Result of movement occurring in the deeper layers and subgrade)

**Note: Manual Spray Patch Treatment not effective.*

Treatments

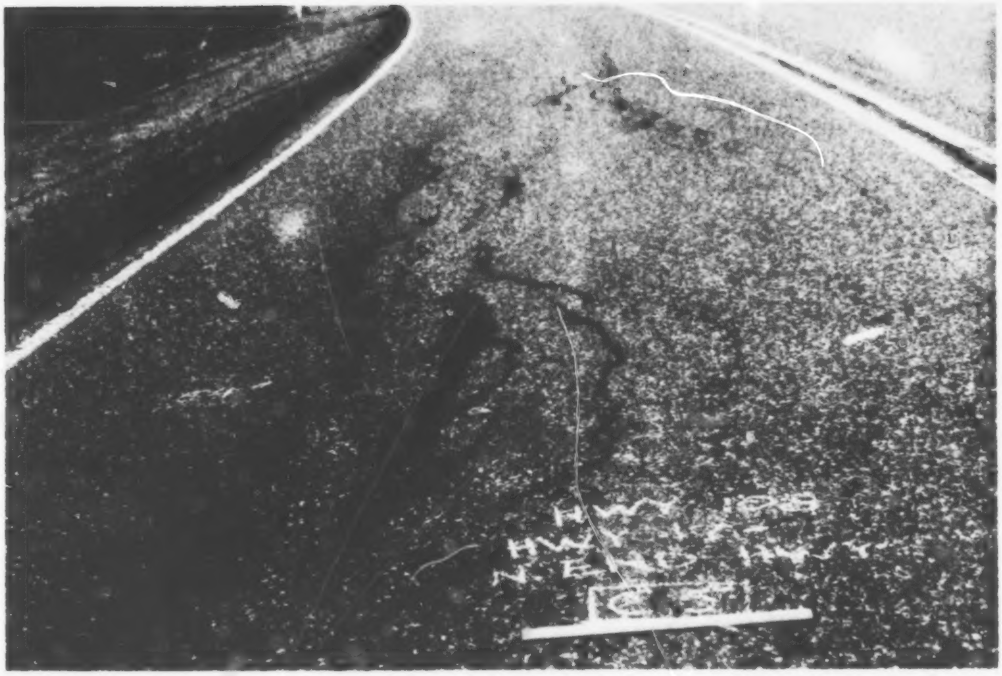
Evaluation		Suggested Remedial Measure Alternatives
Severity	**Density**	
Very Slight	Few	• None
	Intermittent	• None
	Frequent	• None
	Extensive	• None
	Throughout	• None
Slight	Few	• None
	Intermittent	• Manual Chip Seal
	Frequent	• Manual Chip Seal
	Extensive	• Manual Chip Seal • Machine Patching
	Throughout	• Machine Chip Seal • Machine Patching
Moderate	Few	• Manual Patching
	Intermittent	• Manual Patching • Machine Patching
	Frequent	• Manual Patching • Machine Patching
	Extensive	• Machine Patching • Rehabilitation Candidate
	Throughout	• Machine Patching • Rehabilitation Candidate
Severe	Few	• Manual Patching
	Intermittent	• Manual Patching • Machine Patching
	Frequent	• Machine Patching • Rehabilitation Candidate
	Extensive	• Machine Patching • Rehabilitation Candidate
	Throughout	• Rehabilitation Candidate
Very Severe	Few	• Manual Patching • Machine Patching
	Intermittent	• Machine Patching • Rehabilitation Candidate
	Frequent	• Rehabilitation Candidate
	Extensive	• Rehabilitation Candidate
	Throughout	• Rehabilitation Candidate

Miscellaneous

There are types of cracks which are not specifically described in the above subsections because they are either uncommon or restricted to local areas. In all cases of reporting such cracks, the crack should be named or described briefly, and estimates given of its severity and density of occurrence on the "Distress Comments" space provided on the "Flexible Pavement Condition Evaluation Form".

Some examples of these miscellaneous cracks are:

• Slippage Crack	Crack which outlines the edge of a fill settlement. It generally takes the form of a large crescent. The enclosed side of the crescent is depressed, or may have been filled in with surfacing material. Slippage cracks are usually caused by embankment slope failure.
• Tearing Crack	Crescent-shape tearing of the surfacing, likely caused by horizontal forces at a spot where the bond with the underlying layer is very poor.
• Elephant Crack	"Elephant footprint" cracks appear almost exclusively in southern Ontario and on thin pavement design (single course asphalt pavement less than 45 mm over granular grade). There may be a series of these cracks down the centre line of the road, and there may be a slight depression at the centre of the area. Possible causes are a combination of the winter snow removal practice of centre-bare plowing and salting, and porous mix due to either lack of compaction or mix design of the asphalt pavement.



Slippage Crack

Tearing Crack

Elephant Footprint Crack

Slight Elephant Footprint Crack

6/ Paved Shoulder Distress Manifestations

Paved Shoulder Cracking

Pavement Edge, Shoulder (or Curb) Separation

Paved Shoulder Breakup

Paved Shoulder Distortion

Paved Shoulder Cracking

Description:

Cracking distresses occur in stabilized or paved shoulders in the same way as in pavement of similar type. Therefore, the same descriptions are applicable.

Possible Causes:

1. Differential frost action.
2. Settlement.
3. Traffic loads.

Severity:

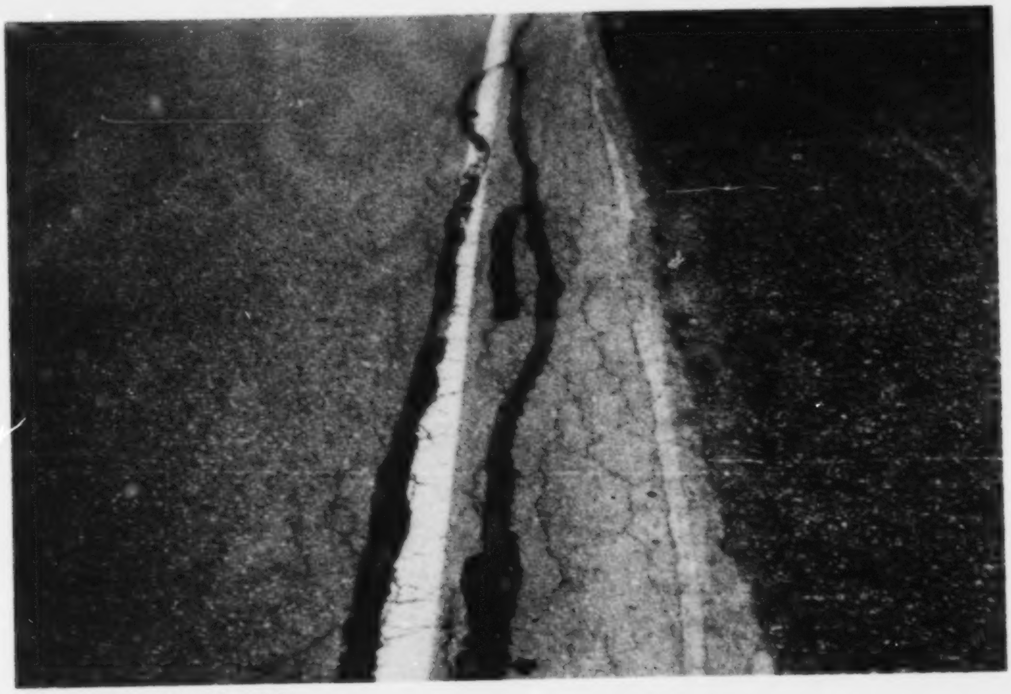
See descriptions for various cracking distresses.

Density:

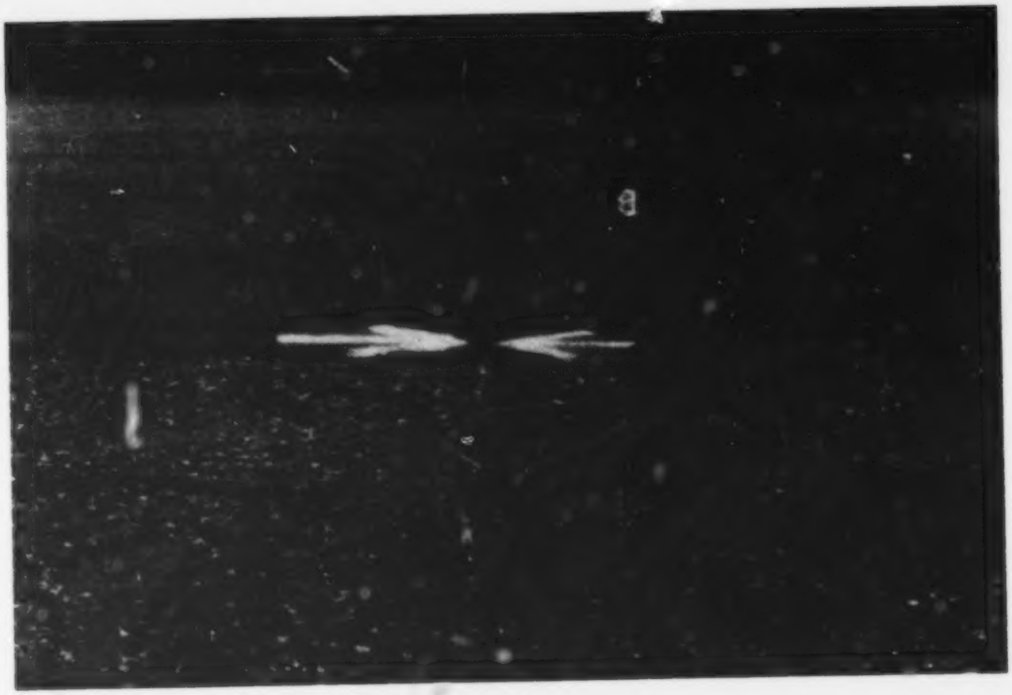
See descriptions for various cracking distresses.

Treatments:

See recommended maintenance treatment alternatives for various cracking distresses.



Paved Shoulder Cracking



Transverse Crack of Surface Treated Shoulder

Pavement Edge, Paved Shoulder (or Curb) Separation

Description: The longitudinal joint between the pavement lane and the paved shoulder (or curb/gutter) is opened or separated.

Possible Causes:

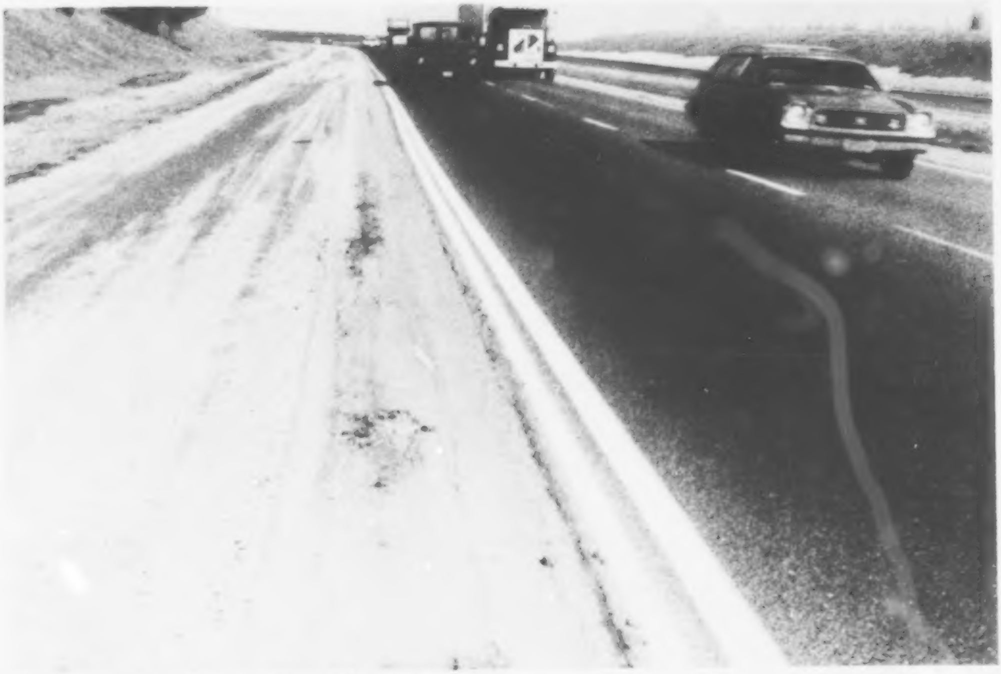
1. Movement due to differential frost action and settlement.
2. Contraction of asphalt pavement in low temperatures is not fully recovered when pavement warms up, resulting in a gap between curb/gutter and pavement surface, which grows wider year after year.
3. Failure of sealant material used in the longitudinal joint of pavement lane and paved shoulder, or curb and gutter.
4. Cracking.

Severity:

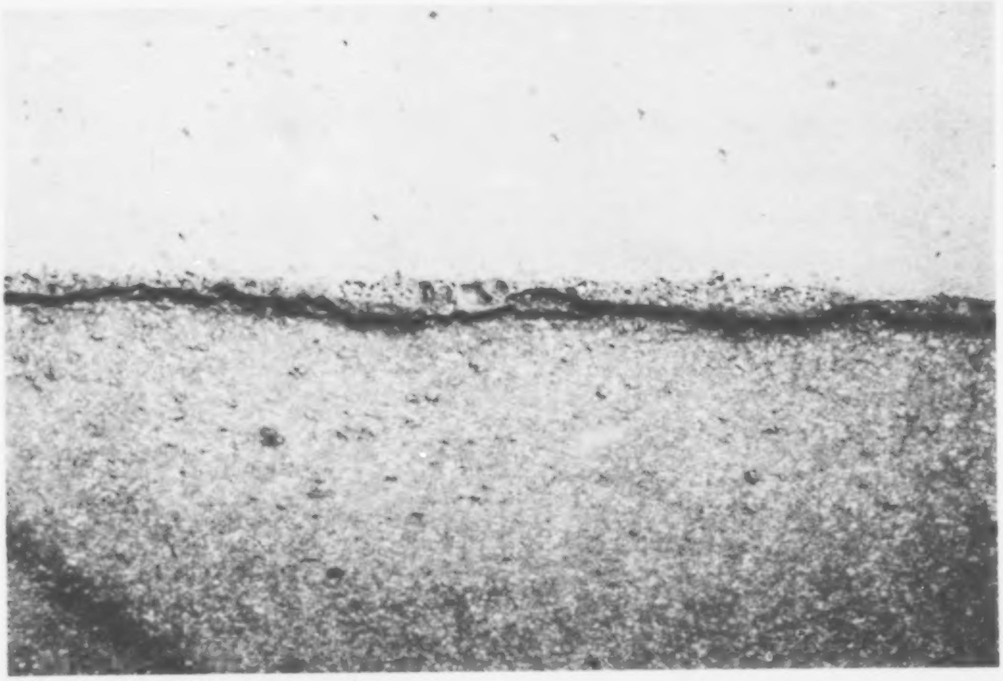
Class	Guidelines
Moderate	13 mm to 19 mm opening with or without multiple cracking.
Severe	Greater than 19 mm opening with or without multiple cracking.

Density:

Class	Guidelines
Intermittent	Less than 20% of pavement surface affected. Distress spotted in localized areas only.
Frequent	20 to 50% of pavement surface affected. Distress spotted evenly over length of pavement or in localized areas.
Extensive	Greater than 50% of pavement surface affected. Distress spotted evenly over length of pavement.



Pavement Edge Paved Shoulder Separation



Pavement Edge Curb Separation

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Moderate	Intermittent	• Rout and seal • Clean and seal
	Frequent	• Rout and seal • Clean and seal
	Extensive	• Rout and seal • Clean and seal
Severe	Intermittent	• Rout and seal • Clean and seal
	Frequent	• Rout and seal • Clean and seal
	Extensive	• Rout and seal • Clean and seal

Paved Shoulder Breakup

Description:	These distresses occur in stabilized or paved shoulders in the same way as in pavement of similar type. Therefore, the same descriptions are applicable.
Possible Causes:	See descriptions for Pavement Edge Break.
Severity:	See descriptions for Pavement Edge Break.
Density:	See descriptions for Pavement Edge Break.
Treatments:	See descriptions for Pavement Edge Break.

Edge Breakup of Stabilized Shoulder

Breakup of Stabilized Shoulder

Paved Shoulder Distortion

Description:

Any deviation of the surface from its original shape. Generally, these distortions result from settlement, from volume changes due to moisture and frost heaving, or from residual effects of frost heaving accumulating after each winter.

Possible Causes:

1. Differential frost action between pavement lane and paved shoulder or curb.
2. Differential settlement of subgrade or materials between pavement lane and paved shoulder or curb.
3. Traffic loading.

Severity:

See description for various distortion distresses.

Density:

See description for various distortion distresses.

Treatments

Evaluation		Suggested Maintenance Treatment Alternatives
Severity	**Density**	
Moderate	Intermittent	• Manual Patching
	Frequent	• Manual Patching
	Extensive	• No action but consider placing on Rehabilitation Program
Severe	Intermittent	• Manual Patching
	Frequent	• No action, but place on Rehabilitation Program
	Extensive	• Rehabilitation Program

7/ Maintenance Treatment Alternatives

Treatment Alternatives

Manual Patching

Machine Patching

Cold Milling or Hot Planing with Manual Patching

Cold Milling or Hot Planing with Machine Patching

Manual Spray Patching

Manual Chip Seal

Machine Chip Seal

Fog Seal

Surface Treatment

Manual Burn and Seal

Crack Rout and Seal

Treatment Alternatives

Description:

When pavement distress leads to a rough surface condition, or to a locally dangerous bump or hole, maintenance is undertaken to do one of the following:

- seal the surface to prevent water from getting down into the susceptible layers; or
- smoothen the roughened surface; or
- cure the cause of the bump or hole.

Maintenance is also undertaken as a long-term preventive measure (*A stitch in time saves nine!*) to do one of the following:

- seal the surface to prevent water from getting down into the susceptible layers; or
- strengthen the structurally inadequate section(s); or
- provide additional drainage facilities to remove any excess moisture from the structure.

A number of remedial measures are listed and illustrated. Treatments are matched against each distress manifestation for possible remedial action.

It is cautioned, however, that the suggestion given as the remedial measure for a particular distress manifestation is not necessarily the most effective, nor will the treatment necessarily effectively correct the cause or causes of the distress. The suggested treatment may be only an expedient measure to slow distress deterioration.

On the other hand, these remedial measures are state-of-the art and represent the best possible alternatives given the availability of equipment and materials in the marketplace.

Patching will cover and hide pavement distress. However, condition reports on the extent and type of patching, when reviewed over a period, will indicate whether the pavement deficiency is due to structural inadequacy, faulty materials, or some other cause.

When the presence of patches is reported, the density of occurrence should be estimated in the terms given in the standard Density table. Similarly, when the presence of sealed cracks is reported, the density of occurrence should be estimated in the terms given in the standard Density table for evaluating cracking.

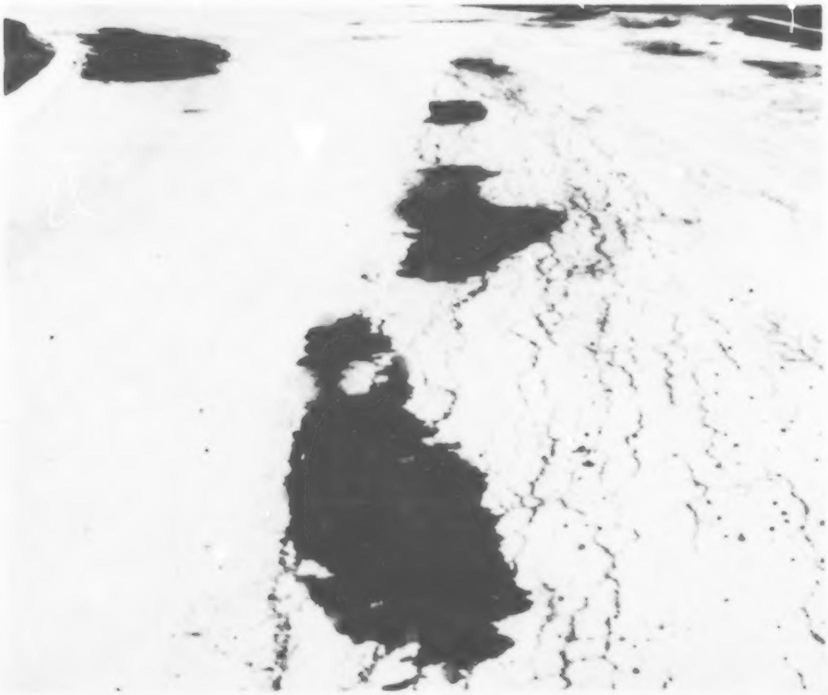
Manual Patching

Description:

The manual placing and spreading of premixed asphaltic materials (hot, cold, or recycled mix) to repair potholes, bumps and depressions and other pavement distresses. Includes preparation of patching area and compaction with or without mechanical aids.

Manual Patching with Recycled Hot-Mix Asphalt

Manual Patching with Hot-Mix Asphalt



Machine Patching

Description:

The machine placing and spreading of premixed asphaltic materials (hot, cold mix) to repair major surface distresses such as alligator cracking, wheel track rutting, distortion, etc. Includes preparation of patching area and compaction with mechanical compactor(s).

Machine Patching with Hot-Mix Asphalt

Cold Milling or Hot Planing with Manual Patching

Description:

The machine removal of pavement surface defects such as distortion, followed by manual patching of milled areas with hot, cold or recycled asphaltic mix, including preparation of patching area and compaction with mechanical compactor(s).

Cold Milling for Manual Patching

Manual Patching with Hot-Mix Asphalt of Cold-Milled Surface

Cold Milling or Hot Planing with Machine Patching

Description:

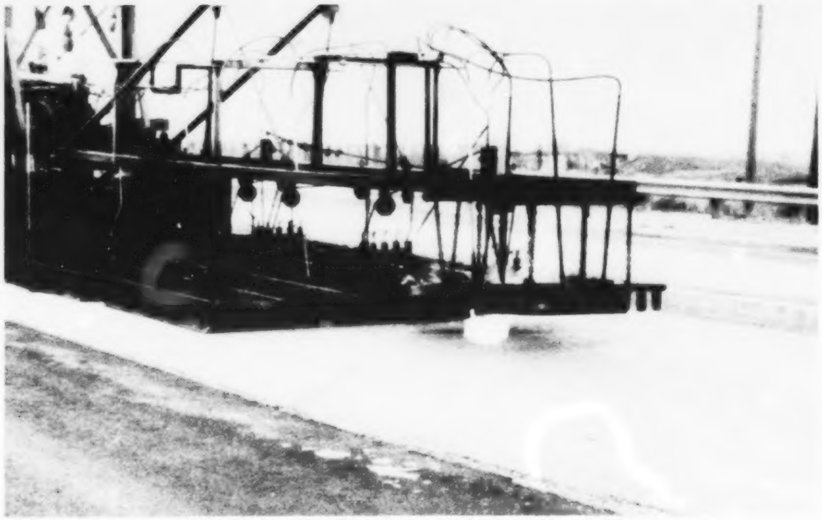
The machine removal of pavement surface defects such as distortion, crack cupping and lipping, etc. followed by mechanical patching of milled surface with hot or recycled asphaltic mix, including preparation of patching area and compaction with mechanical compactor(s).

Cold Milling for Machine Patching

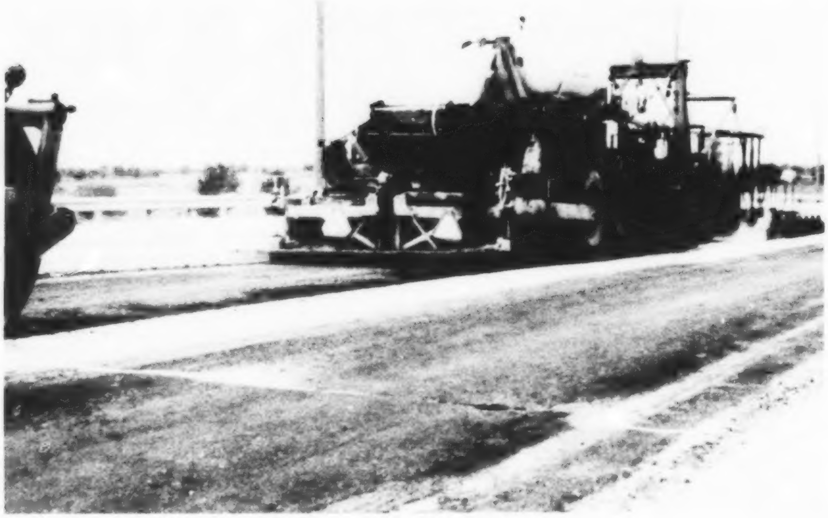
Cold-Milled Surface for Machine Patching

Machine Patching with Hot-Mix Asphalt of Cold-Milled Surface

Hot Planing for Machine Patching



Machine Patching of Hot-Planed Surface



Hot Planing for Machine Patching with Recycling of Existing Pavement and New Hot-Mix Asphaltic Materials

Manual Spray Patching

Description:

The manual application of emulsified asphalt to localized areas of pavement distresses, followed by spreading of aggregate (stone chip or sand) by hand.

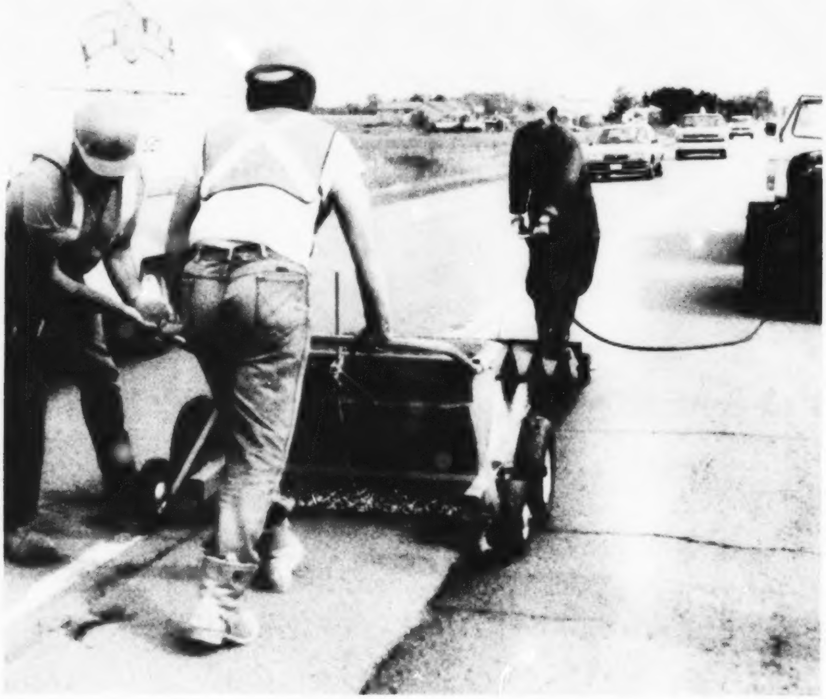
Manual Spray Patching

Manual Chip Seal

Description:

The manual application of emulsified asphalt with a Mini Spray Bar to localized areas of pavement distresses, followed by spreading of selected aggregate (washed stone chips) with a chip spreader and compacted with a mechanical compactor.

Manual Chip Seal with Mini Spray Bar and Chip Spreader



Rolling of Stone Chip as Standard Work Procedure

Manual Chip Seal Treatment

Machine Chip Seal

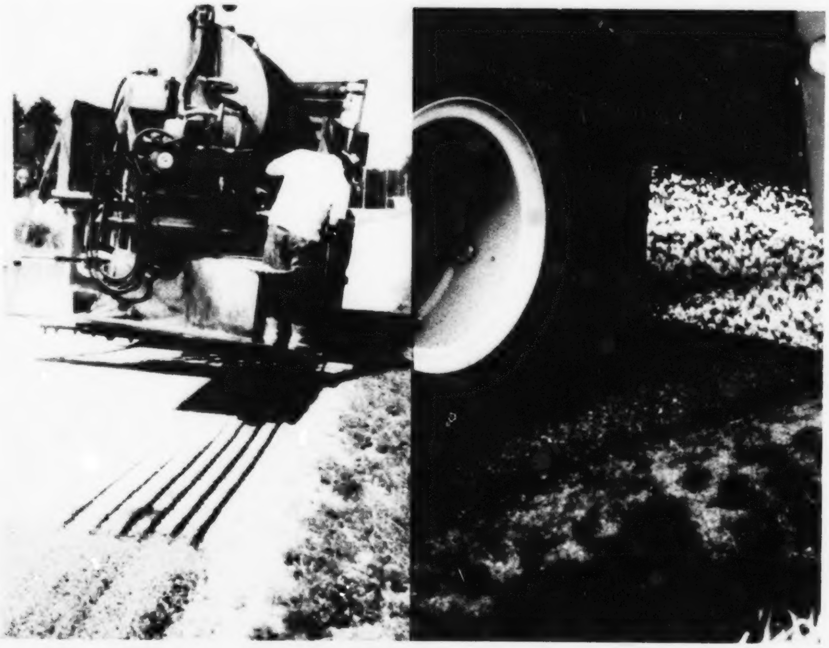
Description:

The machine application of emulsified asphalt to localized areas of pavement distresses, followed by machine spreading of selected aggregate and compacted with mechanical compactor(s).

DYNAPAC
HR21

Machine Chip Seal

Machine Chip Sealed Pavement



Machine Chip Seal Operation

Fog Seal

Description:

The machine application of slow-setting asphalt emulsion diluted with water to renew asphalt surfaces and to seal small cracks and surface voids, etc, followed by machine spreading of sand or usually without as a standard practice.

Fog Sealing

Surface Treatment

Description:

The machine application of emulsified asphalt to continuous sections of road surface, followed by spreading of aggregate with a mechanical spreader, and compaction by mechanical compactors.

Surface-Treatment Equipment Train

Surface-Treatment Spraying Emulsion

Spreading Stone Chips

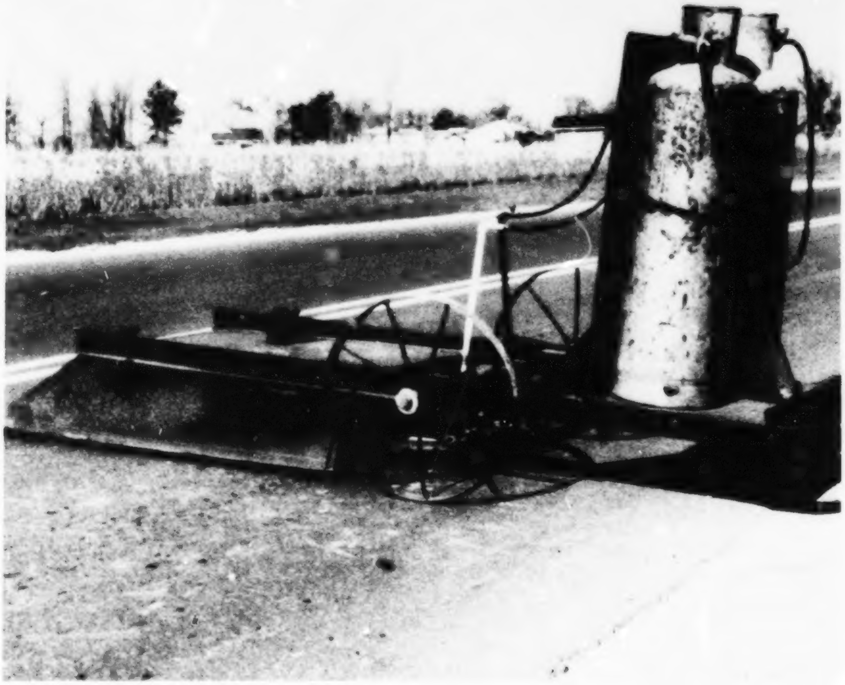
Rolling of Finished Surface Treatment

Manual Burn and Seal

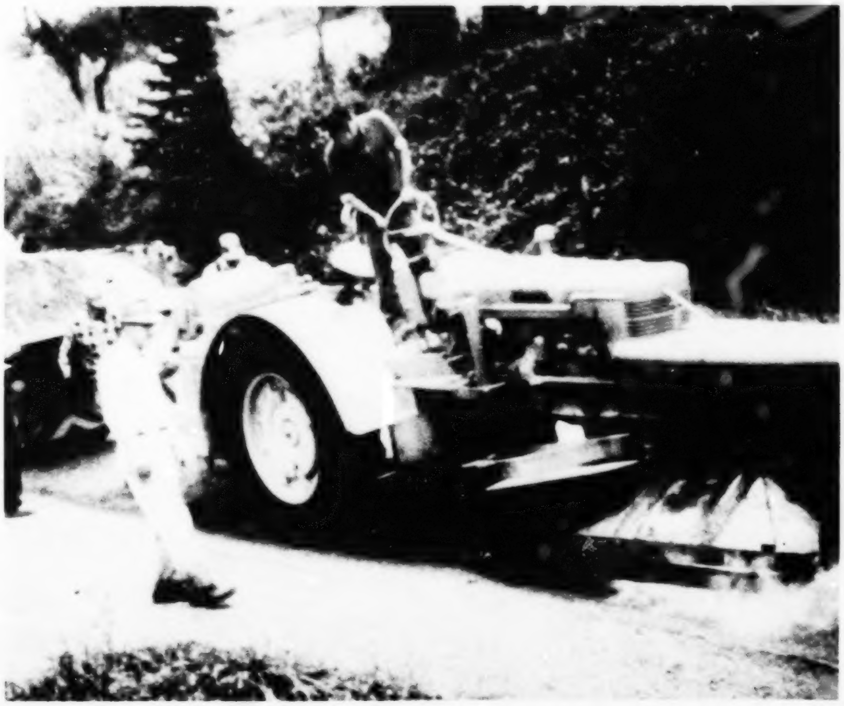
Description:

The elminination of excess surface asphalt by open flame burning unit and sealed with heated aggregate or manual chip seal.

Asphalt Pavement Burner



Burn and Seal Operation



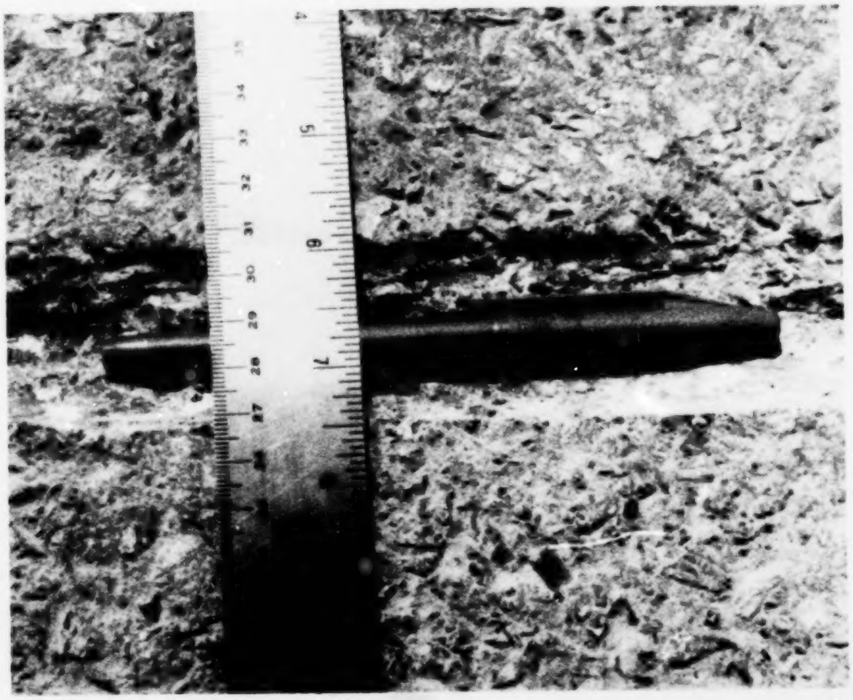
Crack Rout and Seal

Description:

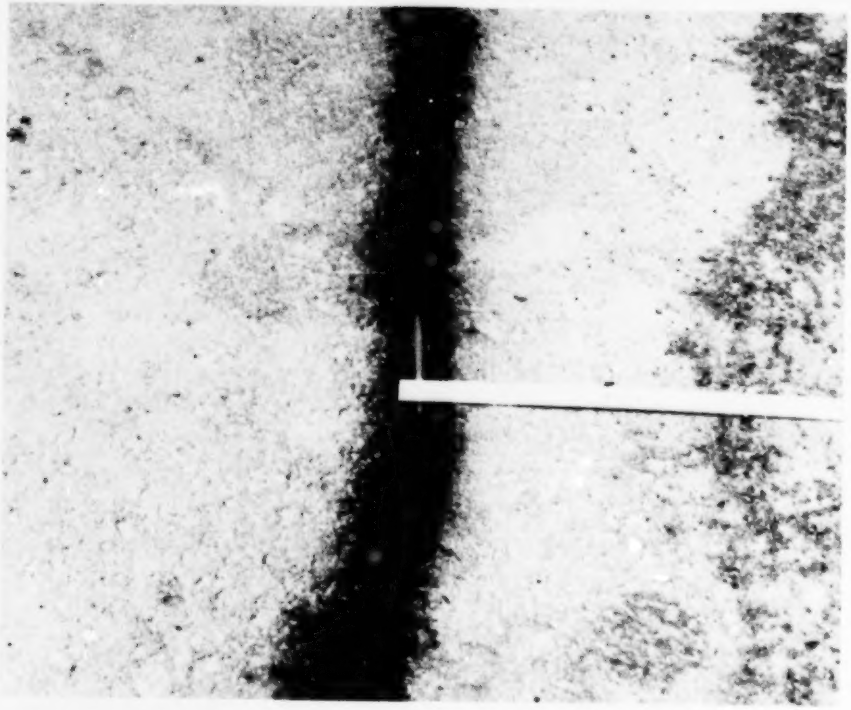
The machine routing, heated compressed air cleaning and drying of the routed crack, and sealing with polymerized asphalt sealant of cracking distresses.

Rout and Seal Operation

Routed Crack



Dry and Clean with Heat Lance



Sealed with Hot-Pour Polymerized Asphalt

References

This "Manual for Condition Rating of Flexible Pavements – Distress Manifestations" was the first (1975) of a series of manuals for pavement condition evaluation published by this Ministry. Therefore, all other manuals and publications related to this subject matter made reference to this particular manual. However, as a matter of reference interest, the following is a list of these related documents:

[1] **Chong, G.J.,** "A Rideability Rating Experiment," Report IR-19, Ministry of Transportation and Communications, Ontario, Canada, 1968.

[2] **Chong, G.J., Phang, W.A., Wrong, G.A.,** "Manual for Condition Rating of Rigid Pavements – Distress Manifestations," Ministry of Transportation and Communications, Ontario, Canada, 1977.

[3] **Chong, G.J., Jewer, F.W., Macey, K.,** "Pavement Maintenance Guidelines – Distresses, Maintenance Alternatives and Performance Standards," Report SP-001, Ministry of Transportation and Communications, Ontario, Canada, 1980.

[4] **Chong, G.J., Phang, W.A., Jewer, F.W.,** "Choosing Cost-Effective Maintenance," Report PAV-80-03, Ministry of Transportation and Communications, Ontario, Canada, 1980. Presented at the Roads and Transportation Association of Canada, Toronto, 1980. Also presented at the Annual Meeting of the Transportation Research Board, Washington, D.C., 1981.

[5] **Blum, W.E., Phang, W.A.,** "Preventive Pavement Maintenance Concepts," Report PAV-80-04, Ministry of Transportation and Communications, Ontario, Canada, 1981.

[6] **Phang, W.A., Chong, G.J.,** "Ontario Flexible Pavement Distress Assessment for Use in Pavement Management," Report PAV-81-01, Ministry of Transportation and Communications, Ontario, Canada, 1981. Presented at the Transportation Research Board, Washington, D.C., 1982. Also presented at the Canadian Technical Asphalt Association Conference, Edmonton, Alberta, November, 1982.

[7] **Phang, W.A., Lefevre, R.N., James, H.H., Matthews, J.D., Nicholls, W., Pattison, H., Sheflin, M.J.,** "Pavement Management Systems – Guidelines for Municipalities," Report PAV-83-05, Ministry of Transportation and Communications, Ontario, Canada, 1983.

[8] **Hajek, J.J., Phang, W.A., Wrong, G.A., Prakash, A., Stott, G.M.,** "Pavement Condition Index (PCI) for Flexible Pavements," Report PAV-86-02, Ministry of Transportation and Communications, Ontario, Canada, 1986.

[9] **Chong, G.J., Phang, W.A., Wrong, G.A.,** "Manual for Condition Rating of Surface Treated Pavements – Distress Manifestations," Ministry of Transportation, Ontario, Canada, 1989.

[10] **Chong, G.J., Phang, W.A., Wrong, G.A.,** "Manual for Condition Rating of Flexible Pavements – Guidelines for Municipalities," Report SP-022, Ministry of Transportation, Ontario, Canada, 1989.

Appendix A.
A Guide for Completing the "Flexible Pavement Condition Evaluation Form"

Pavement Identification

Pavement sections under evaluation must be identified by completing the following (refer also to Figure A-1).

1. Location: tie into the nearest town or city, major highway interchange, or any prominent landmarks.
2. Linear Highway Retrieval System (LHRS) numbers for evaluation section.
3. Offset distance for evaluation section as related to LHRS point.
4. Evaluation section's length in kilometres.
5. District: number of district (1-20).
6. Date of survey: time evaluation took place.
7. Highway: number of highway.
8. Contract number.
9. Work project number.
10. Traffic direction of survey.
11. Facility of pavement lane surveyed.
12. Class of highway.

Riding Quality (RCR)

The riding quality rating of an evaluation section is made by driving over the pavement at the posted speed. The rating is recorded in the proper column on the evaluation form (Figure A-1).

Pavement Surface Distress Manifestations

Pavement surface distress manifestations are evaluated by the rater walking and/or driving very slowly over the evaluation section, and checking off all the pavement distress manifestations in their appropriate spaces (Figure A-1).

The pavement distresses are listed under three subgroups.

1. Surface distress	• loss of coarse aggregate/ravelling/segregation • flushing

2. Surface distortion or deformation
    - rippling and shoving
    - wheel track rutting
    - distortion
3. Cracking
    - longitudinal wheel track
    - longitudinal meander and mid-lane
    - centre line
    - pavement edge
    - transverse
    - map
    - alligator
    - miscellaneous (for any type of cracking which is not specifically described by the above)

Shoulders

Shoulder type should be reported. Distresses, if any, should be evaluated and their density and severity of occurrence reported by checking off the appropriate spaces (Figure A-1).

Maintenance

Maintenance should be reported by its type and density of occurrence, by checking off the appropriate spaces (Figure A-1).

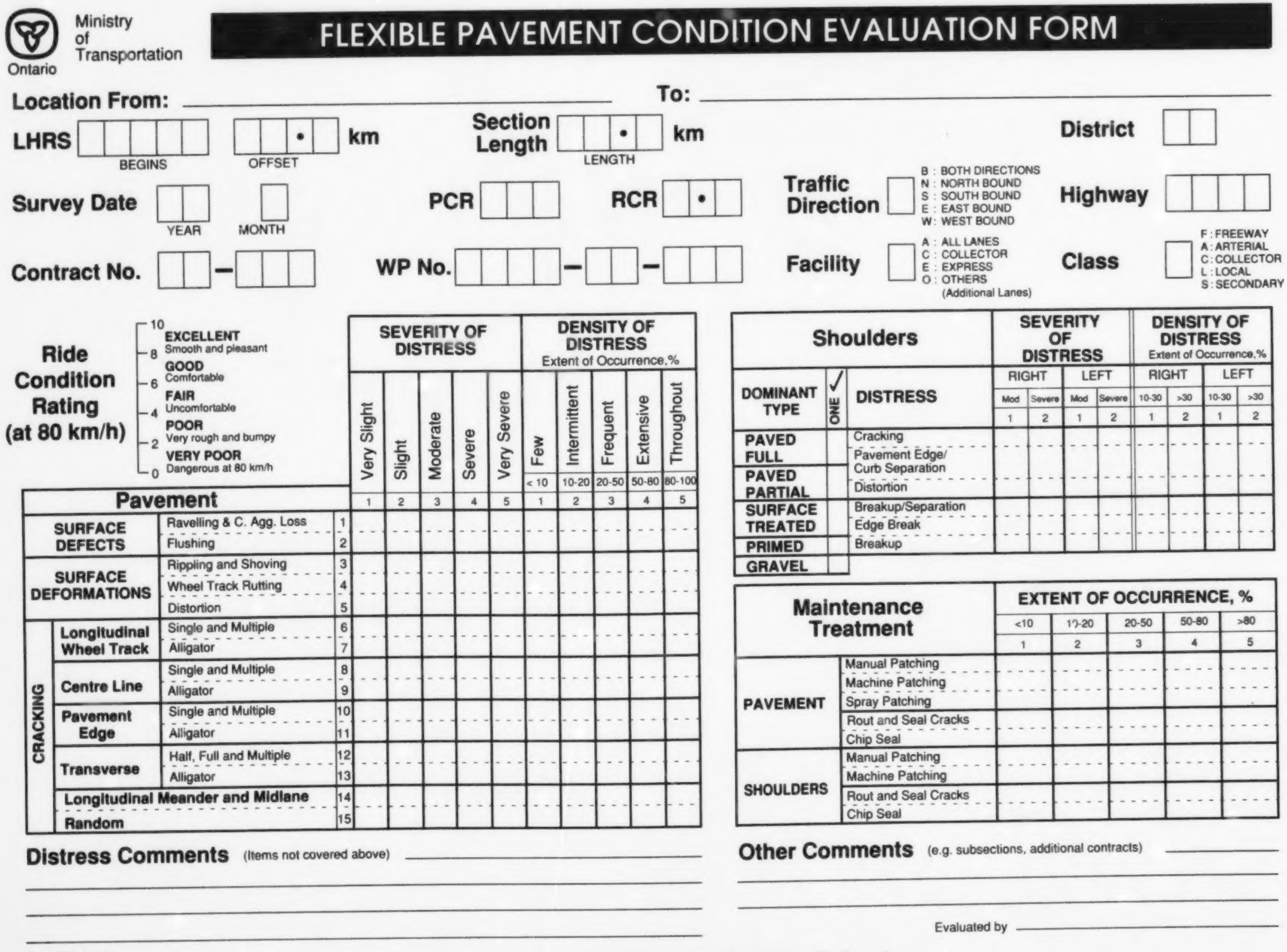
Comments

Items not covered or other significant factors which might influence pavement performance should be reported in their appropriate spaces (Figure A-1).

Pavement Condition Rating (PCR)

Pavement Condition Rating is a subjectively derived rating of serviceability based on an evaluation of pavement riding comfort and of pavement surface distresses such as distortion, cracking, alligatoring, and so on. PCR is an assessment of overall pavement performance, both functionally and structurally, as related to actual observable pavement characteristics — roughness and various distress manifestations.

The Pavement Condition Rating is assigned according to the guidelines provided in Table B-1. The guidelines also suggest the type and timing of maintenance activities or rehabilitation appropriate for the Pavement Condition Rating.



Ontario Ministry of Transportation

FLEXIBLE PAVEMENT CONDITION EVALUATION FORM

Location From: ______________________ **To:** ______________________

LHRS ☐☐☐☐☐ (BEGINS) ☐☐☐•☐ (OFFSET) km

Section Length ☐☐•☐ (LENGTH) km

District ☐☐

Survey Date ☐☐ (YEAR) ☐ (MONTH)

PCR ☐☐☐

RCR ☐•☐

Traffic Direction ☐
B : BOTH DIRECTIONS
N : NORTH BOUND
S : SOUTH BOUND
E : EAST BOUND
W : WEST BOUND

Highway ☐☐☐☐

Contract No. ☐☐ — ☐☐☐

WP No. ☐☐☐☐ — ☐☐ — ☐☐☐

Facility ☐
A : ALL LANES
C : COLLECTOR
E : EXPRESS
O : OTHERS
(Additional Lanes)

Class ☐
F : FREEWAY
A : ARTERIAL
C : COLLECTOR
L : LOCAL
S : SECONDARY

Ride Condition Rating (at 80 km/h)

10–8	**EXCELLENT** Smooth and pleasant
8–6	**GOOD** Comfortable
6–4	**FAIR** Uncomfortable
4–2	**POOR** Very rough and bumpy
2–0	**VERY POOR** Dangerous at 80 km/h

Pavement			SEVERITY OF DISTRESS					DENSITY OF DISTRESS Extent of Occurrence,%				
			Very Slight	Slight	Moderate	Severe	Very Severe	Few	Intermittent	Frequent	Extensive	Throughout
								< 10	10-20	20-50	50-80	80-100
			1	2	3	4	5	1	2	3	4	5
SURFACE DEFECTS	Ravelling & C. Agg. Loss	1										
	Flushing	2										
SURFACE DEFORMATIONS	Rippling and Shoving	3										
	Wheel Track Rutting	4										
	Distortion	5										
CRACKING Longitudinal Wheel Track	Single and Multiple	6										
	Alligator	7										
CRACKING Centre Line	Single and Multiple	8										
	Alligator	9										
CRACKING Pavement Edge	Single and Multiple	10										
	Alligator	11										
CRACKING Transverse	Half, Full and Multiple	12										
	Alligator	13										
CRACKING Longitudinal Meander and Midlane		14										
CRACKING Random		15										

Shoulders			SEVERITY OF DISTRESS				DENSITY OF DISTRESS Extent of Occurrence,%			
			RIGHT		LEFT		RIGHT		LEFT	
DOMINANT TYPE	ONE ✓	DISTRESS	Mod	Severe	Mod	Severe	10-30	>30	10-30	>30
			1	2	1	2	1	2	1	2
PAVED FULL		Cracking								
		Pavement Edge/ Curb Separation								
PAVED PARTIAL		Distortion								
SURFACE TREATED		Breakup/Separation								
		Edge Break								
PRIMED		Breakup								
GRAVEL										

Maintenance Treatment		EXTENT OF OCCURRENCE, %				
		<10	10-20	20-50	50-80	>80
		1	2	3	4	5
PAVEMENT	Manual Patching					
	Machine Patching					
	Spray Patching					
	Rout and Seal Cracks					
	Chip Seal					
SHOULDERS	Manual Patching					
	Machine Patching					
	Rout and Seal Cracks					
	Chip Seal					

Distress Comments (Items not covered above) ______________________

Other Comments (e.g. subsections, additional contracts) ______________________

Evaluated by ______________________

PH-D-584 86-01

Figure A-1 Pavement Condition Rating Form

Appendix B.
A Guide for Completing "Pavement Condition Report Forms"

District No.

Number of district: 1 to 20.

Hwy. No.

If highway location has more than one number, list all, with the lowest number first (e.g., 7, 15, and 29).

W.P. No.

List the current work project number, if applicable.

Length

Indicate the length in kilometres. If there is a discrepancy between the distance table or map distance and the actual car distance, use the actual car distance if the odometer reads correctly.

Location

The location should be given in reference to the junction of highways or secondary highways, or to city or town limits. Do not refer to small villages, rivers, municipal boundaries, or other landmarks which are not readily identifiable on an official road map.

The sections should run from east to west or from south to north. The current MTO Reference System number of the closest numbered location to the east or south of each end of the project should be given, together with the offset distance (if any) from this location.

Last Contract No.

Indicate the number or numbers of previous contracts on the section of highway. This information will be used for input and retrieval from PAMFIS.

RCR (Ride Condition Rating)

Indicate the Ride Condition Rating to one decimal place (e.g., 6.4), based on an assessment of the ride at posted speed. The following scale should be used:

10 to 8	Excellent
8 to 6	Good
6 to 4	Fair
4 to 2	Poor
2 to 0	Very poor

Pavement

Type:	Indicate surface type only — gravel surface, surface treated, mulch, hot-mix, concrete, etc.
Width:	Measure with tape at the time of survey. If variable, show minimum and maximum widths.
Shoulders:	Estimate width or, if variable, show minimum and maximum widths.

Traffic

Indicate the year of the traffic count, the AADT and SADT, and the percentage of truck traffic if known.

Soils Data

Indicate the topography and soil types. This information may be supplemented by reference to Putnam and Chapman or to regional soil maps, if necessary.

Pavement Structure Data

Indicate any spray patching, hot-mix patching, joint sealing, or other maintenance repair work carried out, and the approximate year the work was done.

Performance and Condition

Provide a detailed summary of riding quality, surface defects, distortion, and cracking. The Manual for Condition Rating of Flexible Pavements describes riding quality and various forms of pavement distress, and details the terminology to be used to describe them. The descriptive terms used in the manual have been standardized, and should be strictly followed to allow accurate comparison of information from various sources.

Remarks

This section should include general comments on points such as the following:

- type of W.P., if this has been assigned
- possible changes in type or volume of traffic
- frost heaves
- ditching
- safety features
- alignment
- possible combination with other projects

If deflection or rebound measurements have been made to assess the strength of the pavement, the results should be indicated here. The type of measurement (i.e., Dynaflect, Benkelman Beam, etc.) should be noted. The data should be presented in standard form (i.e., $\bar{x} + 2\sigma$ values). The time of the survey should be noted, to indicate whether the data represents the maximum spring rebound values or whether it was taken from a single survey at some other time of year.

Roughness measurements, if any, should be indicated, showing the type of machine used and the data, usually in millimetres per kilometre.

Skid resistance measurements should be shown, indicating skid number values and the speed at which the skid number was assessed. The method of measurement (i.e. brake force trailer or stereo photographs) should be indicated.

Proposed Remedial Measures

Indicate if patching or other maintenance measures will be adequate, and indicate the year when these should be carried out. If resurfacing is proposed, indicate the type and thickness of courses required and the extent of any padding.

Program Year

Indicate the present program year, if any, and any suggested changes. If work is required within a 5-year period, indicate the year. If no work is required at present, estimate whether work will be required in 5 to 10 years, or after 10 years. This estimate is of value to the Highway Program Administration Office.

Date of Survey

Indicate the day, month, and year.

Condition Rating

Table B-1 is a guide to assessing condition rating and proposed treatments. The recommendations may be varied according to the class of highway considered.

Distribution

Distribution is made to Regional Staff. Copies should be sent to the District Office and to the appropriate Head Office staff in the following sections:

- Design Evaluation and Pavement Section
- Reference and Inventory Systems Section
- Highway Project Control Section

Table B - 1

A Guide for the Estimation of Pavement Condition Rating and Priority for Flexible Pavements	
0-20	Pavement is in poor to very poor condition with extensive severe cracking, alligatoring and dishing. Rideability is poor and the surface is very rough and uneven.
20-30	Pavement is in poor condition with moderate alligatoring and extensive severe cracking and dishing. Rideability is poor and the surface is very rough and uneven.
30-40	Pavement is in poor to fair condition with frequent moderate alligatoring and extensive moderate cracking and dishing. Rideability is poor to fair and surface is moderately rough and uneven.
40-50	Pavement is in poor to fair condition with frequent moderate cracking and dishing, and intermittent moderate alligatoring. Rideability is poor to fair and surface is moderately rough and uneven.
50-65	Pavement is in fair condition with intermittent moderate and frequent slight cracking, and with intermittent slight or moderate alligatoring and dishing. Rideability is fair and surface is slightly rough and uneven.
65-75	Pavement is in fairly good condition with slight cracking, slight or very slight dishing and a few areas of slight alligatoring. Rideability is fairly good with intermittent rough and uneven sections.
75-90	Pavement is in good condition with frequent very slight or slight cracking. Rideability is good with a few slightly rough and uneven sections.
90-100	Pavement is in excellent condition with few cracks. Rideability is excellent with few areas of slight distortion.
	Note: This table is based on Table B-1 in MTO report SP-004

Figure B - 1 Pavement Condition Report

Ministry of Transportation
Ontario

Regional Geotechnical Section

Pavement Condition Report

Condition Rating

District No. ________ Hwy. No. ____ W.P. No. _________ Length ________________________

Location: ____

Reference No. From ________ To _________ Last Contract No. ______________

Offset Distance ________ _________ R.C.R. _________

Pavement: Type ________ Width _________ Shoulder: Width _________

Traffic: Year _______ A.A.D.T. _________ S.A.D.T. _____ % Trucks ______

Soils Data:

Pavement Structure Data:

Maintenance History:

Performance and Condition:

Remarks:

Proposed Remedial Measures:

Program Year: Present___________ Suggested ______________________

Date of Survey: ________________ Prepared by : ____________________